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A COMPUTER PROGRAM VERSION OF THE BROUWER ORBITAL THEORY WITH OPTIONAL MODIFICATIONS

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CONTENTS

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1. INTRODUCTION

This report describes a program which computes osculating elements and position-velocity vectors in an earth satellite orbit according to the Brouwer theory (Brouwer 1959). Options for certain modifications have been added. Basic orbital data are written on a tape called orbital tape which may be used as input to other programs for further processing.

The program written in Fortran IV for the IBM 360 computer is an adaptation of a program constructed and described by Repass and Chaplick (1965)*. It is intended to further revise and extend the program. In view of these intentions this report is to be considered as an interim report. No concentrated effort has been made to remove all imperfections in the documentation and to check out the program thoroughly. This will be done with the final version. Spot checks have shown that the program is working correctly and is giving correct results.

2. THE BROUWER THEORY

The Brouwer theory (Brouwer 1959) is a first order theory giving expressions for the osculating values of the Keplerian elements of a satellite orbit.

To some degree of accuracy the earth's potential at a point at distance r from the earth's center of mass and at latitude β with respect to the equator is given by (IAU 1962)

$$U = \frac{\mu}{r}\left[1 - \sum_{n=1}^{\infty} J_n \left(\frac{R}{r}\right)^n P_n (\sin \beta)\right] \qquad (1)$$

where $P_n(x)$ is the Legendre polynomial of degree n. The constant $\mu = GM_E$ is the product of the gravitational constant G and the mass M_E of the earth and has the dimension length cubed/time squared. The quantity R is the mean equatorial radius of the earth. The coefficient J_n is called the coefficient of the zonal harmonic of order n or briefly the zonal harmonic of order n or the n'th harmonic. Since the center of mass of earth is taken as origin $J_1 = 0$. The J_n are small quantities. It is customary to consider J_2 as a small quantity of the first order and all J_n with $n > 2$ as small quantities of at least second order.

*The primary purpose of this program is not to study orbits but to use the Brouwer theory in an application.

There are also longitude dependent terms in U which Brouwer neglects together with the zonal harmonics of order $n > 5$. For the purposes of his theory he writes

$$U = \frac{\mu}{r} + \frac{\mu k_2}{r^3}(1 - 3\sin^2\beta) + \frac{\mu A_{30}}{r^4}\left(-\frac{3}{2}\sin\beta + \frac{5}{2}\sin^3\beta\right)$$

$$+ \frac{\mu k_4}{r^5}\left(1 - 10\sin^2\beta + \frac{35}{3}\sin^4\beta\right) \qquad (2)$$

$$+ \frac{\mu A_{50}}{r^6}\left(\frac{15}{8}\sin\beta - \frac{35}{4}\sin^3\beta + \frac{63}{8}\sin^5\beta\right)$$

where

$$\begin{aligned} k_2 &= \frac{1}{2} J_2 R^2 \\ A_{30} &= - J_3 R^3 \\ k_4 &= -\frac{3}{8} J_4 R^4 \\ A_{50} &= - J_5 R^5 \end{aligned} \qquad (3)$$

In addition to the constant μ we shall also use the constant k defined by

$$k^2 = \mu \qquad (4)$$

If a spherical earth were the only attracting body the potential due to the earth would be μ/r, i.e. all J_n with $n \geq 2$ would be zero. The orbit of the satellite would be Keplerian, i.e. the motion would take place in a fixed elliptic orbit according to the laws of Kepler. Using well known formulae, the rectangular coordinates and velocity components in megameters and megameters per hour respectively with respect to the equator and equinox of some epoch may be computed from the Keplerian elements

a = semi-major axis in megameters

e = eccentricity

I = inclination
Ω = right ascension of ascending node } with respect to equator and equinox
ω = argument of perigee
M = mean anomaly
} in degrees

The elements a, e, I, Ω, ω are constants whereas M is a linear function of the time given by

$$M = M_0 + M_1 t \tag{5}$$

where

$$M_1 = k\, a^{-3/2} \tag{6}$$

is the mean motion of the satellite.

If τ is measured in hours and M_1 in degrees per hour then $\tau = 360/M_1$ is the period of revolution of the satellite in its closed orbit.

If a non-spherical earth is assumed, i.e. if the J_n with $n \geq 2$ are no longer all assumed to be zero, the same formulae for computing the coordinates and velocity components may be used but the quantities a, e, I, Ω, ω occurring in these formulae are no longer constants and M is no longer a linear function of the time. The variable values

$$a,\ e,\ I,\ \Omega,\ \omega,\ M$$

occuring in these formulae under the assumption of a non-spherical earth are called the osculating values of the Keplerian elements and are solutions of certain differential equations. It is the purpose of the Brouwer theory to find approximate expressions for the solutions of these differential equations under the assumption that all J_n with $n > 5$ are zero. The deviations of the expressions for the osculating values from the Keplerian values are of order J_2 but it must be mentioned that e occurs as a divisor.

It should be noted that in the following description of the Brouwer theory the unit of length is the megameter, the unit of time the hour and that angles are expressed in degrees. These are not the units employed by Brouwer in his paper.

In the Brouwer theory an epoch T and six constants

$$\left.\begin{array}{ll} a_0 & \text{in megameters} \\ e_0 & \\ I_0 & \\ \Omega_0 & \\ \omega_0 & \text{in degrees} \\ M_0 & \end{array}\right.$$

are chosen. Associated with them a solution of the equations of motion for a, e, I, Ω, ω, M of the form

$$\begin{aligned} a_B &= a_0 + \delta a \\ e_B &= e_0 + \delta e \\ I_B &= I_0 + \delta I \\ \Omega_B &= \Omega_0 + \Omega_{10}\, t + \delta \Omega \\ \omega_B &= \omega_0 + \omega_{10}\, t + \delta \omega \\ M_B &= M_0 + M_{10}\, t + \delta M \end{aligned} \tag{7}$$

is constructed. The subscript B has been added to indicate that we deal here with approximate expressions based on the Brouwer theory proper.

In these expressions t is time in hours from the epoch. The quantities

$$\Omega_{10},\ \omega_{10},\ M_{10}$$

are constants expressed in degrees per hour and are called the secular motions of Ω_B, ω_B, M_B. The linear functions

$$\begin{aligned} \Omega'' &= \Omega_0 + \Omega_{10}\, t \\ \omega'' &= \omega_0 + \omega_{10}\, t \\ M'' &= M_0 + M_{10}\, t \end{aligned} \tag{8}$$

are called the secular portions of Ω_B, ω_B, M_B respectively. The secular portions of a_B, e_B, I_B are the constants defined by

$$\begin{aligned} a'' &= a_0 \\ e'' &= e_0 \\ I'' &= I_0 \end{aligned} \tag{9}$$

and thus have no linear terms.

The secular motion M_{10} of M_B is approximately equal to the mean motion the satellite would have if it were moving in a Keplerian orbit close to the actual orbit and is of the order of 180° per hour for a close earth satellite. It is computed to order J_2^2. No confusion will arise if we call $360/M_{10}$ the period of the satellite even though the actual orbit is not closed and the motion is not periodic. But after a period which is of the order of 2 hours the satellite will return to approximately the same position in space. This is so since M_{10} deviates only by terms at least of the order J_2 from the value it would have in a nearby Keplerian orbit and since Ω_{10} and ω_{10} being at least of order J_2 are also small. Since Ω_{10} and ω_{10} which are computed to order J_2^2 are thus much smaller than M_{10} it will take the secular portions of Ω_B and ω_B to complete an arc of 360° in a time much longer than the period of satellite. In general, times of the order of 100 days are required.

The quantities

δa in megameters

δe

δI, $\delta \Omega$, $\delta \omega$, δM in degrees

are series of periodic terms and are called the periodic perturbations of the respective elements. They are of order J_2 and are computed to that order only.

The Brouwer theory thus represents the osculating elements as the sums of secular portions and periodic perturbations. The periodic perturbations are not necessarily equal to zero at the epoch (t = 0) so that

$$a_0,\ e_0,\ I_0,\ \Omega_0,\ \omega_0,\ M_0$$

are not necessarily equal to the osculating values of

$$a,\ e,\ I,\ \Omega,\ \omega,\ M$$

at the epoch. A theory could have been constructed where this would have been the case but the periodic perturbations would have been much greater and the accuracy of the theory would have suffered.

For this reason

$$a_0,\ e_0,\ I_0,\ \Omega_0,\ \omega_0,\ M_0$$

are called the Brouwer mean elements for epoch T. However, the first three of these quantities are independent of the epoch. The latter three change linearly with the epoch. In particular

a_0 = Brouwer mean semi-major axis in megameters

e_0 = Brouwer mean eccentricity

I_0 = Brouwer mean inclination

Ω_0 = Brouwer mean right ascension of the node

ω_0 = Brouwer mean argument of perigee

M_0 = Brouwer mean mean anomaly

} in degrees

There are two types of periodic terms occurring in the periodic terms. The long-period terms are terms whose periods are long compared with the period of the satellite while the short-period terms have periods of comparable size with the period of the satellite or less. In particular terms whose arguments are linear combinations with small integer coefficients of the secular portions of Ω_B and ω_B are long-period terms.

We thus write

$$\begin{aligned}
\delta a &= \delta_s a \\
\delta e &= \delta_L e + \delta_s e \\
\delta I &= \delta_L I + \delta_s I \\
\delta \Omega &= \delta_L \Omega + \delta_s \Omega \\
\delta \omega &= \delta_L \omega + \delta_s \omega \\
\delta M &= \delta_L M + \delta_s M
\end{aligned} \tag{10}$$

where the subscripts L and S indicate long- and short-period terms respectively. There are no long-period terms in a.

While long-period terms are explicitly written down as Fourier series whose arguments are linear functions of the time, this is not the case for the short-period terms where the true anomaly which is not linear in t is used in the arguments.

The long-period portions of the elements are indicated by primes and are defined to be the sums of the secular portions and the long-period perturbations. Using (8) and (9) and noting that there are no long-period terms in a we find

$$
\begin{aligned}
a' &= a'' &&= a_0 \\
e' &= e'' + \delta_L e = e_0 &&+ \delta_L e \\
I' &= I'' + \delta_L I = I_0 &&+ \delta_L I \\
\Omega' &= \Omega'' + \delta_L \Omega = \Omega_0 + \Omega_{10}\, t &&+ \delta_L \Omega \\
\omega' &= \omega'' + \delta_L \omega = \omega_0 + \omega_{10}\, t &&+ \delta_L \omega \\
M' &= M'' + \delta_L M = M_0 + M_{10}\, t &&+ \delta_L M
\end{aligned}
\tag{11}
$$

The Brouwer expressions for the osculating elements are thus equal to the sums of the long-period portions and the short-period perturbations. Thus

$$
\begin{aligned}
a_B &= a_0 &&+ \delta_s a = a' + \delta_s a \\
e_B &= e_0 &&+ \delta_L e + \delta_s e = e' + \delta_s e \\
I_B &= I_0 &&+ \delta_L I + \delta_s I = I' + \delta_s I \\
\Omega_B &= \Omega_0 + \Omega_{10}\, t + \delta_L \Omega + \delta_s \Omega = \Omega' + \delta_s \Omega \\
\omega_B &= \omega_0 + \omega_{10}\, t + \delta_L \omega + \delta_s \omega = \omega' + \delta_s \omega \\
M_B &= M_0 + M_{10}\, t + \delta_L M + \delta_s M = M' + \delta_s M
\end{aligned}
\tag{12}
$$

Brouwer computes the short-period perturbations by making use of the von Zeipel method (von Zeipel 1916–1918). This method furnishes the short-period perturbations as functions of the long-period portions. However, Brouwer uses in these functions the secular portions e'', I'' instead of the long-period portions e', I'. Since he intended to find the short-period terms to order J_2 only and since his procedure causes an error only of order J_2^2 this is legitimate. We shall come back to this point on page 8.

It should be noted that Brouwer does not compute the periodic perturbations directly but computes first the periodic perturbations in the Delaunay variables

$$L,\ G,\ H,\ l,\ g,\ h$$

which are defined by

$$\begin{aligned} L &= (a\mu)^{1/2} \\ G &= L(1-e^2)^{1/2} \\ H &= G\cos I \\ l &= M \\ g &= \omega \\ h &= \Omega \end{aligned} \tag{13}$$

3. OPTIONAL MODIFICATIONS OF THE BROUWER THEORY

The program input contains an option which allows the computaton of M_{10} according to Kozai rather than according to Brouwer. This is accomplished by adding to the value according to Brouwer, which is of the second order, the difference δM_{10} of the value according to Kozai which is likewise used as far as to order J_2^2 minus the value according to Brouwer. Mathematical details concerning this are given in Appendix C (pp. 189–200).

There is a further option which states whether the long-period terms are to be included or not and another option whether the short-period perturbations are to be included or not. If they are to be included two further options will be available. In one of these the short-period terms are computed, as Brouwer does, with the secular portions e'' and I'', instead of with the long-period portions e' and I' as required by the theory. The error (see page 7) is of the second order and is of no consequence if one limits oneself as Brouwer does to short-period terms of the first order. However, it may be desirable to use second-order short-period terms in the semi-major axis a. Then it is essential to have the short-period terms in a computed with e' and I'. The second option provides for the computation of the short-period terms with e' and I' in a and also e, I, Ω, ω, M.

The second order short-period terms in a are important since they have an appreciable effect on the secular motion of M as computed from the Brouwer mean elements corresponding to a given position-velocity vector using Brouwer's or Kozai's formulation for the mean motion of the mean anomaly.

The values of these short-period terms computed by the program are based on expressions given by Kozai (Kozai 1962) and may be optionally included in any run with the program being described here. Mathematical details will be found in Appendix C (pp. 189-200).

For the purpose of studying discrepancies with other orbit generators it will be useful to have the option of adding certain terms to the Brouwer expressions even though with the added terms the expressions may no longer correspond to a gravitational solution within the order specified by Brouwer.

The terms that may be added are linear, quadratic, and cubic terms in the time in the semi-major axis, eccentricity, and inclination. The Brouwer theory provides for linear terms in time in the right ascension of the node, the argument of perigee, and the mean anomaly. Any additional linear terms and quadratic and cubic terms may be added. Finally, up to 99 sines and cosines may be added to the six elements. The arguments of the sines and cosines are arbitrary linear functions of the time. The same arguments must be used for each of the six elements. The sum of the sines and cosines for each of the six elements will be referred to as the supplementary perturbation of this element.

The optional additions to the Brouwer theory discussed may be written in the form

$$
\begin{aligned}
\delta_a a &= a_1 t + a_2 (0.01\,t)^2 + a_3 (0.01\,t)^3 + \delta_2 a + \delta_{sup}\, a && \text{in } a \\
\delta_a e &= e_1 t + e_2 (0.01\,t)^2 + e_3 (0.01\,t)^3 + \delta_{sup}\, e && \text{in } e \\
\delta_a I &= I_1 t + I_2 (0.01\,t)^2 + I_3 (0.01\,t)^3 + \delta_{sup}\, I && \text{in } I \\
\delta_a \Omega &= d\Omega_1 t + \Omega_2 (0.01\,t)^2 + \Omega_3 (0.01\,t)^3 + \delta_{sup}\, \Omega && \text{in } \Omega \\
\delta_a \omega &= d\omega_1 t + \omega_2 (0.01\,t)^2 + \omega_3 (0.01\,t)^3 + \delta_{sup}\, \omega && \text{in } \omega \\
\delta_a M &= (\delta M_{10} + dM_1)\, t + M_2 (0.01\,t)^2 + M_3 (0.01\,t)^3 + \delta_{sup}\, M && \text{in } M
\end{aligned}
\qquad (14)
$$

The quantities

a_1 in megameters per hour

e_1 per hour

$I_1, d\Omega_1, d\omega_1, dM_1$ in degrees per hour

define the optional additional linear terms and

a_2 in megameters per (100 hours)^2

e_2 per (100 hours)^2

$I_2, \Omega_2, \omega_2, M_2$ in degrees per (100 hours)^2

and

a_3 in megameters per (100 hours)^3

e_3 per (100 hours)^3

$I_3, \Omega_3, \omega_3, M_3$ in degrees per (100 hours)^3

the optional quadratic and cubic terms. For scaling purposes 100 hours instead of 1 hour is the unit of time in these terms.

The quantity δM_{10} is the optional reduction of the mean motion from Brouwer to Kozai. The quantity $\delta_2 a$ is the sum of the optional second order short-period terms in a and

$$\delta_{sup} a, \quad \delta_{sup} e, \quad \delta_{sup} I, \quad \delta_{sup} \Omega, \quad \delta_{sup} \omega, \quad \delta_{sup} M$$

are the optional supplementary perturbations.

4. THE BASIC ORBIT GENERATOR FUNCTION

The first basic orbit generator function consists in computing complete expressions for the osculating values of the elements

a = semi-major axis in megameters

e = eccentricity

I = inclination

Ω = right ascension of ascending node } with respect to equator and equinox

ω = argument of perigee

M = mean anomaly

} in degrees

at t hours from the epoch by means of the formulae

$$
\begin{aligned}
a &= a_B + \delta_a a \\
e &= e_B + \delta_a e \\
I &= I_B + \delta_a I \\
\Omega &= \Omega_B + \delta_a \Omega \\
\omega &= \omega_B + \delta_a \omega \\
M &= M_B + \delta_a M
\end{aligned}
\qquad (15)
$$

Here the first terms of the right hand members are given by (12) and correspond to the Brouwer theory proper with the added option that the short-period terms may be computed with either e", I" or e', I'. The second terms of the right-hand members represent the optional additional terms given by (14). Their inclusion may cause the osculating values to be no longer consistent with a gravitational solution within the order specified by Brouwer.

To compute the osculating values of the elements for any t the following quantities are required:

Geophysical constants

R = mean equatorial radius of the earth in megameters

GM_E = product of the gravitational constant and mass of the earth in km cubed/seconds squared

J_2, J_3, J_4, J_5 zonal harmonics of orders 2-5

Epoch (calendar date and time of day)

Orbital parameters

Mean Brouwer elements

a_0 semi-major axis in megameters

e_0 eccentricity

I_0 inclination } with respect to equator and equinox

Ω_0 right ascension of ascending node } with respect to equator and equinox

ω_0 argument of perigee } in degrees

M_0 mean anomaly } in degrees

Additional Secular Coefficients

Linear coefficients

rate a_1 in megameters per hour

rate e_1 per hour

motion I, and additional motions $d\Omega_1, d\omega_1, dM_1$ in degrees per hour

Quadratic Coefficients

a_2 in megameters per (100 hours)^2

e_2 per (100 hours)^2

$I_2, \Omega_2, \omega_2, M_2$ in degrees per (100 hours)^2

Cubic Coefficients

a_3 in megameters per (100 hours)^3

e_3 per (100 hours)^3

$I_3, \Omega_3, \omega_3, M_3$ in degrees per (100 hours)^3

Further it must be indicated whether the reduction of the mean motion of the mean anomaly from Brouwer to Kozai, the long-period perturbations, the short-period perturbations, the second order short-period terms in a, and the supplementary perturbations are to be included. If supplementary perturbations are to be included each argument occurring in them is to be defined by giving its value in degrees at an epoch to be specified and its change in degrees per hour and the coefficients of the cosine and sine of this argument in each of the six elements. The epochs to be specified for the arguments may be different for each argument and need not coincide with the epoch of the Brouwer mean elements.

Finally, an indication must be given whether the short-period terms are to be computed with e",I" or e',I'.

If expressions based on the Brouwer theory proper are desired the additional secular coefficients are to be put equal to zero, i.e. one has to use

$$a_1 = e_1 = I_1 = d\Omega_1 = d\omega_1 = dM_1 = 0$$

$$a_2 = e_2 = I_2 = \Omega_2 = \omega_2 = M_2 = 0$$

$$a_3 = e_3 = I_3 = \Omega_3 = \omega_3 = M_3 = 0$$

and choose the options not to include the reduction of the mean motion of the mean anomaly from Brouwer to Kozai, to include the long- and short-period perturbations, to compute the latter with e'', I'', not to include the second order short-period terms in a, and not to include any supplementary perturbations.

The second basic orbit generator function consists in computing for t the rectangular equatorial coordinates

$$x, y, z \quad \text{in megameters}$$

and the equatorial velocity components

$$\dot{x}, \dot{y}, \dot{z} \quad \text{in megameters per hour}$$

This process includes solving Kepler's equation for the eccentric anomaly.

For convenience sake the radius vector in megameters and the eccentric and true anomalies in degrees are included in the output.

The results are arranged in form of one or several ephemerides. For each ephemeris a starting and ending time and a step size must be specified. For each ephemeris point

$$x, y, z, \dot{x}, \dot{y}, \dot{z}$$

and the osculating values are written on an orbital tape. The format is described in Section 9. Information is also written out on the standard output tape at specified frequencies.

5. ALTERNATIVE OPERATIONS OF THE PROGRAM

The input necessary for the basic orbit generator functions has been described in Section 4. However, two alternatives are available.

Instead of the Brouwer mean elements the osculating values

a = semi-major axis in megameters

e = eccentricity

I = inclination

Ω = right ascension of the ascending node } with respect to equator and equinox

ω = argument of perigee

M = mean anomaly

} in degrees

at the epoch may be used in the input. All other quantities of the input must be used as described in Section 4. The program then determines by an iteration process those Brouwer mean elements which together with the remaining quantities of the input would produce the osculating values of the input. After these Brouwer mean elements have been determined the program operates as described in Section 4.

As a second alternative, instead of the Brouwer mean elements, the values of the rectangular equatorial coordinates

$$x, y, z \quad \text{in megameters}$$

and of the rectangular equatorial velocity components

$$\dot{x}, \dot{y}, \dot{z} \quad \text{in megameters per hour}$$

at the epoch may be used in the input. All other quantities of the input must be used as described in Section 4. The program then determines first the values of the osculating elements a, e, I, Ω, ω, M at the epoch and then, as in the preceding case, by an iterative process, those Brouwer mean elements which would produce these osculating values. After these have been found the program operates as described in Section 4.

6. UNITS

The unit of length used in the input described in Section 4 or the alternatives described in Section 5 is the megameter. The unit of time is the hour. Angles are given in degrees. Velocity components and coefficients of linear terms are given per hour and coefficients of the quadratic and cubic terms in t are given per $(100 \text{ hour})^2$ and $(100 \text{ hours})^3$ respectively.

Other orbit generator programs have used other units. An alternate choice of units is possible with the present program. So called canonical units may be used instead of the units described above. The canonical unit of length (cul) is the mean equatorial radius of the earth and the canonical unit of time (cut) is that unit which together with the canonical unit of length causes the constant μ in expressions (1) and (2) for the earth's potential to be unity. It is

$$R^{3/2} \, (GM)^{-1/2} \quad \text{seconds}$$

if R is measured in cm and GM_E in $cm^3 \, sec^{-2}$.

Coefficients of the linear terms are then expressed per cut and coefficients of quadratic and cubic terms per $(cut)^2$ and $(cut)^3$ respectively.

7. BRIEF DESCRIPTION OF THE PROGRAM

The main program is designated as P73. It requires the following subroutines (SR) and function programs except for library routines. Subroutines are called and function programs indicated by * are merely used by name without the command CALL.

ADLH	BRWR4	KOMEAN	SSWTCH
ALLOT*	DJUL*	MAD*	SUPP0
ATANQ*	DMAD*	PARA	SUPP1
ATANZ*	ELRV	POLVAL	TIMC4
BBRWR	HMSRZ*	RHMSZ	WRT6
BRWR1	JULCAL	RVELZ	XKEP*
BRWR2			

The listings for P73 and the subroutines listed above are given in Appendix A (pp. 21-172). An index appears on p. 22.

All routines except for

ADLH, BRWR4, KOMEAN, POLVAL, SSWTCH, SUPP0, SUPP1, WRT6

were contained, possibly under a slightly different name, in the original Repass program package.

SR ADLH is a slight modification of a program ADDL described by Agreen and Fisher (1968). SR BRWR4 is a modification of BRWR2, and KOMEAN, POLVAL, SUPP0, SUPP1, and WRT6 have been designed by the author. SSWTCH is a routine simulating the sense switches of the IBM 7094 machines.

In the listings for P73, BRWR4, and all other routines originating from a routine of the Repass program package except in the case of DMAD and MAD, the following information or parts of it, often appear:

Purpose (Brief description of function of program or routine)
Calling sequence to be used
Input
Output
Reference
Method
Restrictions
Accuracy
Required subprograms
Timing
Analysis

This information appears also in the listing for BRWR4. Above information in many cases is, however, characterized as not available. The list of required subprograms refers only to first level subprograms, i.e. a program called by a subprogram of some routine is not listed.

In case of the routines where a list of required subprograms is not given the required subprograms may be ascertained from the compilation.

A brief description of the present program package follows.

The main program, P73, reads the input except for the ephemeris specifications which are read by TIMC4, and the specifications for the supplementary perturbations which are read by SUPP0 if required.

The action of PARA depends on which of the three alternative input options discussed in Sections 4 and 5 are used. If Brouwer mean elements are used in the input PARA determines the values of the osculating elements at the epoch by employing the basic orbit generator functions to be described in some detail below. If the values of the osculating elements at the epoch are used in the input no processing occurs in PARA. Finally, if the position-velocity vector at the epoch is used in the input then the values of the osculating elements at the epoch are determined by RVELZ. No further processing occurs.

Thus in every case, after completion of PARA, the values of the osculating elements at the epoch will be available. With the help of ELRV the position-velocity vector at the epoch is determined. In case the values of the osculating elements at epoch or the position-velocity vector at epoch, were used in the input, i.e. if the Brouwer mean elements were not used in the input, they are now determined. This will be done by BBRWR using an iterative process. If the Brouwer mean elements are used in the input then BBRWR is bypassed. In every case a point in the program is reached when the Brouwer mean elements are known and the basic orbit generator functions discussed in Section 4 may be carried out.

These functions start out with the Brouwer mean elements. The coefficients of the secular and long-period terms are computed in BRWR1. This need be done just once regardless how many ephemeris points are to be processed. If the reduction of the mean motion of the mean anomaly from Brouwer to Kozai is to be included it is found from KOMEAN.

For the epoch and every ephemeris point to be processed, the expressions for the long-period terms are evaluated and the short-period perturbations are computed. Then the complete values of the osculating elements are formed and the position-velocity vector is obtained. All these tasks are accomplished by BRWR2 or BRWR4 according to whether e", I" or e', I' are used in the computation of the short-period perturbations. If the second order short-period

terms in a are to be included a call in BRWR2 and BRWR4 to ADLH is necessary.* If supplementary perturbations are to be included then a call in BRWR2 and BRWR4 to SUPP1 is necessary. After the complete values of the osculating elements have been formed in BRWR2 or BRWR4 the position-velocity vector is determined with the help of ELRV. One step in this procedure consists in solving Kepler's equation which requires the use of XKEP.

The writing of the orbital tape is done in the main program P73 by WRT6.

Several routines and function programs have not yet been mentioned in this brief description. ALLOT reduces an angle modulo 2π. ATANZ and ATANQ find an angle from its sine and cosine or its sine and cosine multiplied by a constant respectively. DJUL and JULCAL are used in converting from calendar date to Julian day and vice versa. DMAD and MAD compute remainders from divisions. HSMRZ and RHMSZ convert from hours, minutes, seconds to radians and from radians to days, hours, minutes, seconds respectively. Finally, POLVAL computes polynomials.

8. DESCRIPTION OF INPUT DECK

The cards of the input deck are described in the listings in Appendix A of the programs where they are read. For convenience sake the relevant information alone is listed in Appendix B (pp. 173-187).

Several cases may be run. For each case there are cards numbered 1-9 with several cards for some numbers, in which case distinguishing letters and numbers are used. Some of the cards are omitted under special conditions. After the last case a number 1 and a number 2 card must follow. The latter must have a 0 in cols. 1-3.

In each case, one or several ephemerides may be computed. Certain data for every ephemeris point are written out on a tape called orbital tape, the format of which is described in Section 9.

The quantity KPR in columns 60-65 of card 9 indicates how often the data for ephemeris points are to be written on the standard output tape.

9. ORBITAL TAPES

The orbital tape is an EBCDIC tape containing double precision data for one or several orbits. Each orbit corresponds to one file on the tape.

---

*In view of the discussion on page 8 it would not be realistic to include the second order short-period terms in a and to compute the short-period terms with e", I".

Each file contains a lead record and orbital data for one or several sets of equidistant dates.

The available orbital data are coordinates, velocities, and osculating elements.

Format

Lead record:

NCASE	orbit number
CASE	object + orbit number (object number is the integral portion, orbit number is the decimal portion)
NTIME	= 0
NPLAN	= 0
NOTHER	= 0
JA(I), I = 1, . . . , 8	= 0
INPUT	= 0
ORB1	= 0.D 00
ORB2	= 0.D 00

Format 1X, I3, F8.3, I5, 2I4, 8I3, I4, 2F8.3

For each ephemeris point there are three record

Record 1: time in minutes from epoch

$\left.\begin{matrix} x \\ y \\ z \end{matrix}\right\}$ in megameters

$\left.\begin{matrix} \dot{x} \\ \dot{y} \\ \dot{z} \end{matrix}\right\}$ in megameters per hour

Format 1X, I5, 6D21.14

Record 2: time in minutes from epoch
0.D 00
0.D 00
0.D 00

Format 1X, I5, 3D23.16

Record 3: time in minutes from epoch

a	osculating value of	semi-major axis in megameters		in degrees
e		eccentricity		
I		inclination	with respect to equator and equinox	
Ω		right ascension of ascending node		
ω		argument of perigee		
M		mean anomaly		

Format 1X, I5, 6D21.14

There are other programs which produce the same type of tape where the quantities which are zero in the lead record are not necessarily zero and where record 2 of the orbital data contains accelerations instead of zeros. A future version of this program will produce these accelerations on the orbital tape.

Orbital tapes may be input to other programs. One such programs forms the differences of orbital data from two orbits which are represented either by two files of one orbital tape or two files from two orbital tapes.

10. DESCRIPTION OF OUTPUT ON STANDARD OUTPUT

After printing the title page, the input options from card 2 of input deck are listed. A statement concerning units follows. With this information, the value of a constant in another orbit generator program, vis SATPOS (Walther and Wales, 1967) is included. After this information, a list of the values used for the required geophysical constants is given. If supplementary perturbations are to be included the arguments and coefficients occurring in these are listed. Then the input orbital parameters in the units used in the input are listed and repeated in the alternate units. Information concerning the tolerance and maximum number of iterations allowed in solving Kepler's equation follows.

A table showing the coefficients of the secular and long-period terms constitutes the next group of data. The basis of the calculation of the mean motion of the mean anomaly is given. The values of the Brouwer mean elements, osculating elements, and the components of the position-velocity vector at the epoch are then shown in several units.

After this ephemeris data are printed. Preceding the data for the individual data points information on the limits of the ephemeris and frequency of printing is given. For each ephemeris point, in general, sixteen lines of numerical data are given in the form of two blocks. The first contains twelve, the second four lines.

The first line of the first block contains the date in several forms and the time from the epoch in minutes. Lines 2-12 give information on various portions of the osculating elements. Line 2 gives the gravitational secular portions, i.e. the values of the secular portions as derived from the Brouwer theory proper with the possible effect of the optional reduction of the mean motion of the mean anomaly from Brouwer to Kozai included. The optional secular terms are given in lines 3-5 leading to the total secular portions on line 6. Line 7 gives the long-period perturbations leading to the long-period portions in line 8. The short-period perturbations, second order short-period perturbations, and supplementary perturbations follow in lines 9-11. The complete values of the osculating elements are then given in line 12, the last line of the first block.

The first line of the second block lists the radius vector, eccentric and true anomalies. The next two lines show the number of iterations required to solve Kepler's equation and the last relative correction obtained for the approximation to the solution. The final line of the block contains the values of the components of the position-velocity vector.

There are some options to be specified in the input which allow additional output to be printed, i.e. detailed output of some phases of the computations. These additional outputs are printed if certain fields of columns on card 2 of the input deck contain quantities not zero. If a zero is in one of these fields the corresponding output will not be printed.

If the quantity in cols. 19-21 of card 2 of the input deck is not zero intermediate output from BRWR1 will be printed. It is not labelled. For identification the program listing of BRWR1 must be consulted.

If the quantity in cols. 43-45 of card 2 of the input deck is not zero intermediate output from KOMEAN will be printed. It is not labelled. For identification the program listing of KOMEAN must be consulted.

If the second order short-period terms in a are desired and if the quantity in cols. 31-33 of card 2 of the input deck is not zero details of the computation of the second order short-period terms in a are given for all ephemeris points for which data are given in the standard output. There is little labelling in this detailed output, which appears between lines 1 and 2 of the first block of twelve lines referred to above. Identification should be made with the help of the program listings of ADLH, BRWR2, or BRWR4.

Finally, if supplementary perturbations are desired and if the quantity in cols. 37-39 of card 2 of the input deck is not zero intermediate quantities in the computation of the supplementary perturbations are printed for every ephemeris point for which data are printed in the standard output. This additional output is labelled and appears also between lines 1 and 2 of the first block of twelve lines referred to above.

APPENDIX A

PROGRAM LISTINGS

INDEX

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          COMPILER OPTIONS - NAME=   P73,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
                CMAIN P73                                                                                    00045120
ISN 0002              IMPLICIT REAL*8(A-H,O-Z,$)                                                             00045130
                C      MUSTAP PROGRAM   VERSION 2  THEORY AND ANALYSIS OFFICE - GSFC                         00045140
                C                                                                                            00045150
                C                                                                                            00045160
                C     1A. CONVERTS OSCULATING ORBITAL ELEMENTS TO INERTIAL POSITION                          00045170
                C           AND VELOCITY RECTANGULAR COORDINATES.                                            00045180
                C     1B. CONVERTS INERTIAL POSITION AND VELOCITY RECTANGULAR                                00045190
                C           COORDINATES TO OSCULATING ORBITAL ELEMENTS.                                      00045200
                C                                                                                            00045210
                C     ALL INTERNAL CALCULATIONS ARE PERFORMED USING THE KILOMETER AS                         00045220
                C     THE UNIT OF LENGTH AND THE SECOND AS THE UNIT OF TIME.  IF ANY                         00045230
                C     OF THE OPTIONAL INPUT PARAMETERS ARE DEFINED IN OTHER UNITS,                           00045240
                C     THEY ARE CONVERTED TO THESE UNITS AS SOON AS THEY ARE READ IN                          00045250
                C     AND ARE SUBSEQUENTLY USED IN THE CALCULATIONS IN KILOMETERS                            00045260
                C     AND SECONDS.                                                                           00045270
                C                                                                                            00045280
                C     THE ORBIT REQUIRED                                                                     00045290
                C     IS GENERATED BY SUBROUTINES BRWR1 AND BRWR2 (DIRK BROUWER -                            00045300
                C     SOLUTION OF THE PROBLEM OF ARTIFICIAL SATELLITE THEORY WITHOUT                         00045310
                C     DRAG)                                                                                  00045320
                C                                                                                            00045330
                C     REQUIRED SUBROUTINES AND FUNCTIONS                                                     00045340
                C     ALLH                                                                                   00045350
                C     ALLOT                                                                                  00045360
                C     ATANQ                                                                                  00045370
                C     ATANZ                                                                                  00045380
                C     BBRWR                                                                                  00045390
                C     BRWR1                                                                                  00045400
                C     BRWR2                                                                                  00045410
                C     BRWR4                                                                                  00045420
ISN 0003       1001 CONTINUE                                                                                 00045430
                C     DJUL                                                                                   00045440
                C     DMAD                                                                                   00045450
                C     ELRV                                                                                   00045460
                C     HMSRZ                                                                                  00045470
                C     JULCAL                                                                                 00045480
                C     KOMEAN                                                                                 00045490
                C     MAC                                                                                    00045500
                C     PARA                                                                                   00045510
                C     RHMSZ                                                                                  00045520
                C     RVELZ                                                                                  00045530
                C     SUPP0                                                                                  00045540
                C     SUPP1                                                                                  00045550
                C     TIMC4                                                                                  00045560
                C     WRT6                                                                                   00045570
                C     XKEP                                                                                   00045580
                C                                                                                            00045590
ISN 0004              DOUBLE PRECISION LPCOEF                                                                00045600
ISN 0005              DIMENSION        RX(3),VX(3) ,A(6),AI(24),VXE(3),                                      00045610
                     1GP(5),LA(6),DAD(6),A110(6),XX(12),AB(6),RXB(3) ,                                       00045620
                     2VXB(3),XXX(10),SS(3),DUM1(100),XHEAD(12),                                              00045630
                     3          A11BR(6),A1BR(6),ABR(6),RXBM(3),VXBM(3),                                     00045640
                     4          DLL(6),DLS(6)            ,                                                   00045650
                     5          EL(13),LPCOEF(7,6),RATE(7),                                                  00045660
                     6          A110BR(6),AINPUT(24),AIDH(24),                                               00045670
```

```
                     7          DUM2(85),DUMF(9)                                                    00045680
                     8          AG(6),D1(6),D2(6),D3(6)                                             00045690
                     9          AGBR(6),D1BR(6),D2BR(6),D3BR(6) ,ACC(3),JA(12)                      00045700
ISN 0006              DIMENSION T0(99),ARG0(99),ARGMOT(99),ARG(99),CCOEF(99,6),                    00045710
                     1SCOEF(99,6),DSUP(6),ASHORT(6),ASHR(6),RXBMC(3),VXBMC(3),DADIN(6)            00045720
ISN 0007              DIMENSION KSW(6)                                                            00045730
ISN 0008           1000 CONTINUE                                                                  00045740
ISN 0009              COMMON DUM1,A110,GP,ERR ,XX,AB,RXB,VXB,XXX,SS,EL,DUM2,DUMF,                 00045750
                     1CONV,AIDH,AG,D1,D2,D3 ,CMU,T0,DJ0,DTIMES,ARG0,ARGMOT,ARG,CCOEF,            00045760
                     2SCOEF,DSUP,CJ2S,CJ3,CJ4,DLJ2S,DLJ3,DLJ4,DLSUM,DAJ2S,DAJ3,DAJ4,             00045770
                     3DASUM,REM , ASHORT,                                                        00045780
                     4          NBRWR1,NLONG,NSHORT,NSEC,NSECD,NSUPP,NSUPPD,NARG,KCOUNT00045790
                     5,NKOZ,NKOZD                                                                00045800
ISN 0010              COMMON /LABL1/ REML,TUH                                                     00045810
                    C                                                                            00045820
                    C     DEFINITION OF SYMBOLS                                                  00045830
                    C                                                                            00045840
                    C     ERR = TRUNCATION FACTOR (IN RADIANS) USED IN SOLUTION OF               00045850
                    C     KEPLERS EQUATION                                                       00045860
                    C     GM = PRODUCT OF G (=GAUSSIAN CONSTANT SQUARED) AND M, THE MASS OF      00045870
                    C     THE EARTH, IN UNITS OF KM. CUBED/SEC SQUARED                           00045880
                    C     FJ2=J2 )                                                               00045890
                    C     FJ3=J3 ) HARMONICS OF EARTHS GRAVITATIONAL POTENTIAL                   00045900
                    C     FJ4=J4 ) (DIMENSIONLESS)                                               00045910
                    C     FJ5=J5 )                                                               00045920
ISN 0011           1003 CONTINUE                                                                  00045930
                    C     RE= EQUATORIAL RADIUS OF EARTH IN KM.                                  00045940
                    C                                                                            00045950
                    C                                                                            00045960
                    C     ALL FORMATS USED IN PROGRAM FOLLOW IMMEDIATELY.                        00045970
                    C                                                                            00045980
ISN 0012           1800 FORMAT(1H1)                                                              00045990
ISN 0013           1801 FORMAT(1X,19HOSCULATING ELEMENTS,15X,F15.7,F17.9,F11.5,3F15.5)           00046000
ISN 0014           1802 FORMAT(1X,16HSECULAR PORTIONS,18X,F15.7,F17.9,F11.5,3F15.5)              00046010
ISN 0015           1803 FORMAT(1X,25HLONG PERIOD PERTURBATIONS,9X,F15.7,F17.9,F11.5,3F15.500046020
                    1)                                                                           00046030
ISN 0016           1804 FORMAT(1X,20HLONG PERIOD PORTIONS,14X,F15.7,F17.9,F11.5,3F15.5)           00046040
ISN 0017           1805 FORMAT(1X,20HX,Y,Z,XDOT,YDOT,ZDOT,14X,6F15.7)                            00046050
ISN 0018           1806 FORMAT(1X,26HSHORT PERIOD PERTURBATIONS, 8X,F15.7,F17.9,F11.5,           00046060
                    13F15.5)                                                                     00046070
ISN 0019           1808 FORMAT(      94H              A                E                 I       00046080
                    1        NODE              OMEGA              M)                             00046090
ISN 0020           1810 FORMAT(//91HCOEFFICIENTS OF LONG PERIOD PERTURBATIONS (ARGUMENTS 00046100
                    1ARE N TIMES SECULAR PORTION OF OMEGA)/98HON            A                    00046110
                    2 E                I            NODE              OMEGA            M       00046120
                    3     PI/1H0,56X,6HCOSINE/4H01  ,2F14.8,3F14.6,2F16.6/4H 2  ,2F14.800046130
                    4,3F14.6,2F16.6/4H 3  ,2F14.8,3F14.6,2F16.6/)                                00046140
ISN 0021           1811 FORMAT(1H0,57X,4HSINE/4H01  ,2F14.8,3F14.6,2F16.6/4H 2  ,2F14.8,3F00046150
                    114.6,2F16.6/4H 3  ,2F14.8,3F14.6,2F16.6/)                                   00046160
ISN 0022           1816 FORMAT(53X,26HIN EARTH RADII AND RADIANS/)                               00046170
ISN 0023           1817 FORMAT(//53X,25HIN MEGAMETERS AND DEGREES/)                              00046180
ISN 0024           1818 FORMAT(////58X,20HIN KM AND KM PER SEC/)                                 00046190
ISN 0025           1819 FORMAT(59X,13HMEAN ELEMENTS//)                                           00046200
ISN 0026           1820 FORMAT(///56X,19HOSCULATING ELEMENTS//)                                  00046210
ISN 0027           1821 FORMAT(61X, 9HRV VECTOR//)                                               00046220
ISN 0028           1822 FORMAT(1X,14HCANONICAL UNIT,3X,D24.16,3X,7HSECONDS,5X,D24.16,3X,         00046230
```

```
     15HHOURS)                                                                  00046240
ISN 0029      1823 FORMAT(1X,1HK,3X,D24.16)                                     00046250
ISN 0030      1825 FORMAT(//48X,37HIN MEGAMETERS AND MEGAMETERS PER HOUR/)      00046260
ISN 0031      1827 FORMAT(1X,38HCONSTANT CON1 USED IN SATPOS PROGRAM =,5X,D24.16///) 00046270
ISN 0032      1830 FORMAT(72X)                                                  00046280
ISN 0033      1831 FORMAT(1H1,54X,24HINPUT ORBITAL PARAMETERS////)              00046290
ISN 0034      1832 FORMAT(1X,43HRV-VECTOR IN MEGAMETERS,MEGAMETERS PER HOUR,6X, 00046300
          13(D24.17,3X)/50X,3(D24.17,3X)//)                                     00046310
ISN 0035      1833 FORMAT(1X,45HRV-VECTOR IN EARTH RADII,EARTH RADII PER CUT.,4X, 00046320
          13(D24.17,3X)/50X,3(D24.17,3X)//)                                     00046330
ISN 0036      1834 FORMAT(1X,39HMEAN ELEMENTS IN MEGAMETERS AND DEGREES,10X,    00046340
          13(D24.17,3X)/50X,3(D24.17,3X)//)                                     00046350
ISN 0037      1835 FORMAT(1X,40HMEAN ELEMENTS IN EARTH RADII AND RADIANS, 9X,   00046360
          13(D24.17,3X)/50X,3(D24.17,3X)//)                                     00046370
ISN 0038      1836 FORMAT(1X,45HOSCULATING ELEMENTS IN MEGAMETERS AND DEGREES,4X, 00046380
          13(D24.17,3X)/50X,3(D24.17,3X)//)                                     00046390
ISN 0039      1837 FORMAT(1X,46HOSCULATING ELEMENTS IN EARTH RADII AND RADIANS,3X, 00046400
          13(D24.17,3X)/50X,3(D24.17,3X)//)                                     00046410
ISN 0040      1838 FORMAT(1X,48HCOEFF. OF ADD'L LIN. TERMS OF ELEMENTS, PER  HR.,1X, 00046420
          13(D24.17,3X)/50X,3(D24.17,3X)//)                                     00046430
ISN 0041      1839 FORMAT(1X,48HCOEFF. OF ADD'L LIN. TERMS OF ELEMENTS  PER CUT.,1X, 00046440
          13(D24.17,3X)/50X,3(D24.17,3X)//)                                     00046450
ISN 0042      1840 FORMAT(1X, 47HCOEFF.OF QUADR. TERMS      PER (100 HRS) SQUARED,2X, 00046460
          13(D24.17,3X)/50X,3(D24.17,3X)//)                                     00046470
ISN 0043      1841 FORMAT(1X, 47HCOEFF.OF QUADR. TERMS      PER (CUT    ) SQUARED,2X, 00046480
          13(D24.17,3X)/50X,3(D24.17,3X)//)                                     00046490
ISN 0044      1842 FORMAT(1X, 47HCOEFF.OF CUBIC  TERMS      PER (100 HRS) CUBED  ,2X, 00046500
          13(D24.17,3X)/50X,3(D24.17,3X)//)                                     00046510
ISN 0045      1843 FORMAT(1X, 47HCOEFF.OF CUBIC  TERMS      PER (CUT    ) CUBED  ,2X, 00046520
          13(D24.17,3X)/50X,3(D24.17,3X)//)                                     00046530
ISN 0046      1844 FORMAT(1X,20HGRAV.SECULAR PORTION,   14X,F15.7,F17.9,F11.5,3F15.5) 00046540
ISN 0047      1845 FORMAT(1X,23HADDTL.TERMS LINEAR IN T,11X,F15.7,F17.9,F11.5,3F15.5) 00046550
ISN 0048      1846 FORMAT(1X,20HTERMS QUADRATIC IN T,   14X,F15.7,F17.9,F11.5,3F15.5) 00046560
ISN 0049      1847 FORMAT(1X,20HTERMS CUBIC     IN T,   14X,F15.7,F17.9,F11.5,3F15.5) 00046570
ISN 0050      1848 FORMAT(1X,30H2ND ORDER SHORT-PER.TERMS IN A, 4X,F15.7)       00046580
ISN 0051      1849 FORMAT(1X,27HSUPPLEMENTARY PERTURBATIONS,7X,F15.7,F17.9,F11.5, 00046590
          13F15.5)                                                              00046600
ISN 0052      1851 FORMAT(14X,15I7)                                             00046610
ISN 0053      1852 FORMAT(59X,13HINPUT OPTIONS///14X,                    105H   00046620
          1 INPUT   NCST   NERR    NDA    IRC  NUNIT NBR#R1  NLONG NSHORT   N00046630
          2SEC  NSECD  NSUPP NSUPPD   NKOZ  NKOZD//)                          00046640
ISN 0054      1854 FORMAT(1H1,55X,21HGEOPHYSICAL CONSTANTS///)                  00046650
ISN 0055      1855 FORMAT(////26X, 80HADDITIONAL TERMS LINEAR IN T,QUADRATIC AND CUBIC 00046660
          1C TERMS IN T NOT LISTED FOR EPOCH/52X,19HSINCE THEY ARE ZERO/////) 00046670
ISN 0056      1857 FORMAT(37X, 58HALL LENGTHS IN MEGAMETERS,TIMES IN HOURS,ANGLES IN 00046680
          1DEGREES/55X,22HUNLESS OTHERWISE NOTED/51X,31HALL TIMES ARE IN EPHE 00046690
          2MERIS TIME)                                                          00046700
ISN 0057      1858 FORMAT(1H1,48X,34HINPUT CONVERTED TO ALTERNATE UNITS////)    00046710
ISN 0058      1859 FORMAT(     38X,1HA,26X,1HE,26X,1HI/                         00046720
          136X,4HNODE,23X,5HOMEGA,24X,1HM////)                                  00046730
ISN 0059      1860 FORMAT(27X,3(D24.17,3X))                                     00046740
ISN 0060      1861 FORMAT(/////38X,1HX,26X,1HY,26X,1HZ/                         00046750
          136X,5HX DOT,22X,5HY DOT,22X,5HZ DOT////)                             00046760
ISN 0061      1862 FORMAT(47X,38HIN EARTH RADII AND EARTH RADII PER CUT/)       00046770
ISN 0062      1863 FORMAT(////40X,52HTOLERANCES USED IN DETERMINING BROUWER MEAN ELEM00046780
          1ENTS///)                                                             00046790
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ISN 0063      1864 FORMAT(///47X,29HNUMBER OF ITERATIONS REQUIRED,3X,I6)                    00046800
ISN 0064      1865 FORMAT(8X,6(D10.4,6X))                                                  00046810
ISN 0065      1866 FORMAT(//44X,36HMAXIMUM NUMBER OF ITERATIONS ALLOWED,3X,I6)             00046820
ISN 0066      1867 FORMAT(1X,33HNO. OF IT. IN SOLV. KEPLER'S EQ'N,I8)                      00046830
ISN 0067      1868 FORMAT(1X,38HLAST REL. CORR. IN SOLV. KEPLER'S EQ'N,D10.2)              00046840
ISN 0068      1869 FORMAT(1H1,27X,52HTOLERANCE USED IN SOLV. KEPLER'S EQ'N FOR (E2-E100046850
                  1)/E2,3X,  D8.2,3X /44X,36HMAXIMUM NUMBER OF ITERATIONS ALLOWED,3X,00046860
                  2I5)                                                                    00046870
ISN 0069      1870 FORMAT(12X,5HNZERO,20X,7HNODE 10,17X,8HOMEGA 10,21X,4HM 10,22X,5HP00046880
                  1I 10)                                                                  00046890
ISN 0070      1871 FORMAT(1X,5(D24.17,2X)///)                                              00046900
ISN 0071      1872 F..MAT(     62X,7HMOTIONS//)                                            00046910
ISN 0072      1873 FORMAT(     62X,1HA,26X,1HE,26X,1HI/                                    00046920
                  160X,4HNODE,23X,5HOMEGA,24X,1HM////)                                    00046930
ISN 0073      1874 FORMAT(40X,53HMOTIONS AND COEFFICIENTS OF LONG PERIOD PERTURBATION00046940
                  1S)                                                                     00046950
ISN 0074      1875 FORMAT(1H1,38X,56HMEAN ELEMENTS,OSCULATING ELEMENTS,AND RV VECTOR 00046960
                  1AT EPOCH)                                                              00046970
ISN 0075      1876 FORMAT(1H1,57X,18HDATA FOR THE EPOCH)                                   00046980
ISN 0076      1877 FORMAT(1H1,57X,9HEPHEMERIS,3X,I6/////)                                  00046990
ISN 0077      1878 FORMAT(///26X,80HE1 AND E2 ARE TWO SUCCESSIVE APPROXIMATIONS TO TH00047000
                  1E SOLUTION OF KEPLER'S EQUATION)                                       00047010
ISN 0078      1879 FORMAT(1X,27HRAD.VECT.,ECC. AND TRUE AN.,7X,F15.7,28X,F15.5,15X,  00047020
                  1F15.5)                                                                 00047030
ISN 0079      1880 FORMAT(///29X,46HTO EXPRESS LENGTHS IN CANONICAL UNIT DIVIDE BY,  00047040
                  13X,D24.17/29X,52HTO EXPRESS VELOCITIES IN CANONICAL UNITS MULTIPLY00047050
                  2 BY,3X,D24.17)                                                         00047060
ISN 0080      1881 FORMAT(40X,18HANOMALISTIC PERIOD,3X,D24.17,3X,5HHOURS///)               00047070
ISN 0081      1882 FORMAT(///58X,5HORBIT,3X,F8.3///)                                       00047080
ISN 0082      1883 FORMAT(///22X,87HTHE SHORT PERIOD TERMS ARE COMPUTED WITH E" AND I00047090
                  1" AS SPECIFIED BY BROUWER,AJ,NOV. 1959)                                00047100
ISN 0083      1884 FORMAT(///49X,34HNO SHORT PERIOD TERMS ARE INCLUDED)                    00047110
ISN 0084      1885 FORMAT(///  9X,113HTHE SHORT PERIOD TERMS ARE COMPUTED WITH E' AND 00047120
                  1I' INSTEAD OF WITH E" AND I" AS SPECIFIED BY BROUWER,AJ,NOV. 1959)00047130
ISN 0085      1886 FORMAT(18X,6HNUMBER,3X,I6,3X,77HOF ARGUMENTS IN SUPPLEMENTARY PER-00047140
                  1TURBATIONS IS NOT A POSITIVE INTEGER LE.99.)                           00047150
ISN 0086      1887 FORMAT(20X,65HREDUCTION OF MEAN MOTION OF MEAN ANOMALY FROM BROUWE00047160
                  1R TO KOZAI = ,3X,D24.17//)                                             00047170
ISN 0087      1888 FORMAT(42X,49HMEAN MOTION OF MEAN ANOMALY COMPUTED ACCORDING TO)  00047180
ISN 0088      1889 FORMAT(62X, 7HBROUWER//)                                                00047190
ISN 0089      1890 FORMAT(33X,66HKOZAI BY APPLYING REDUCTION TO VALUE COMPUTED ACCORD00047200
                  1ING TO BROUWER//)                                                      00047210
ISN 0090      3999 FORMAT(1X,I3,F8.3,I5,2I4,8I3, I4,2F8.3)                                 00047220
ISN 0091      6002 FORMAT (12A6)                                                           00047230
ISN 0092      6003 FORMAT(15I3)                                                            00047240
ISN 0093      6004 FORMAT (D12.6,4D12.5/ D24.17)                                           00047250
ISN 0094      6005 FORMAT (                                    //1X0PF8.3,1X34H  E00047260
                  1QUATORIAL RADIUS OF EARTH IN KM/                                       00047270
                  2   1X,1PD14.8,3X31H GM (KM. CUBED/SECONDS SQUARED)//18X45H  HARMGN00047280
                  3ICS OF EARTHS GRAVITATIONAL POTENTIAL/1XD13.6,4X3H J2/1X,D13.6,4X 00047290
                  43H J3/1X,D13.6,4X3H J4/1X,D13.6,4X3H J5)                               00047300
ISN 0095      6006 FORMAT( I3,F8.3,3I2,1X,2I2,1X,F4.2       /3D24.17/3D24.17/3D24.17/00047310
                  13D24.17/3D24.17/3D24.17/3D24.17/3D24.17)                               00047320
ISN 0096      1004 CONTINUE                                                                00047330
ISN 0097      6010 FORMAT(////33X,4HJD =,3X,D24.17,5X,7H EPOCH ,I4,4(1X,I2),1X,       00047340
                  1F6.0///)                                                               00047350
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ISN 0098      6039 FORMAT (13H JOB FINISHED/////)                                    00047360
ISN 0099      6040 FORMAT( D8.2,I4)                                                 00047370
ISN 0100      6041 FORMAT (28H1EXECUTE MAIN PROGRAM-WMAPLA/1H1)                      00047380
ISN 0101      6050 FORMAT(6D8.2)                                                    00047390
ISN 0102      6083 FORMAT(                    44X,1HA,15X,1HE,12X,1HI,12X,4HNODE,   00047400
             111X,5HOMEGA,12X,1HM)                                                  00047410
ISN 0103      6085 FORMAT(11X,4HJD =,3X,D24.17,5X,                                  00047420
             1              I4,1X,2(I2,1X),2X,2(I2,1X),2X,F4.1,9X,26HTIME FROM E00047430
             2POCH IN MINUTES,3X,F11.3/)                                           C0047440
                C                                                                  00047450
                C                                                                  00047460
                C                                                                  00047470
ISN 0104              DO 8002 I=1,6                                                00047480
ISN 0105      8001 KSW(I)=0                                                        00047490
ISN 0106      8002 CALL SSWTCH(I+6,KSW(I))                                         00047500
ISN 0107           KPAGE=0                                                       00047510
ISN 0108           KEF=0                                                         00047520
ISN 0109           MEFL=27                                                       00047530
ISN 0110           DO 100 I=1,3                                                  00047540
ISN 0111       100 ACC(I)=0.D 00                                                 00047550
ISN 0112           DO 8058 J=1,6                                                 00047560
ISN 0113      8058 DSUP(J)=0.D 00                                                00047570
ISN 0114           PI=3.14159265358979 3D+00                                     00047580
ISN 0115           CONV=180.D+00/PI                                              00047590
ISN 0116           PRINT 6041                                                    00047600
                C                                                                  00047610
                C     DEFINE TRUNCATION FACTOR (RADIANS)                           00047620
                C                                                                  00047630
ISN 0117      5042 CALL SLITET(2,LCP023)                                           00047640
ISN 0118           GO TO (1,1),LCP023                                            00047650
ISN 0119         1 ERR=1.0D-14                                                   00047660
ISN 0120           NMAX=50                                                       00047670
                C     DEFINE TRUNCATION FACTORS FOR SUBROUTINE BBRWR ( USED TO CONVERT 00047680
                C     OSCULATING ELEMENTS TO BROUWER MEAN ELEMENTS)                00047690
                C                                                                  00047700
                C                                                                  00047710
                C     DAD(1) IS IN KM, DAD(3) - DAD(6) IN DEGRRES                  00047720
                C                                                                  00047730
ISN 0121           DAD(1)=5.0D-11                                                00047740
ISN 0122           DAD(2)=5.0D-15                                                00047750
ISN 0123           DAD(3)=5.0D-12                                                00047760
ISN 0124           DAD(4)=5.0D-12                                                00047770
ISN 0125           DAD(5)=5.0D-12                                                00047780
ISN 0126           DAD(6)=5.0D-12                                                00047790
ISN 0127           DADIN(1)=DAD(1)/1.D 03                                        00047800
ISN 0128           DADIN(2)=DAD(2)                                               00047810
ISN 0129           DADIN(3)=DAD(3)                                               00047820
ISN 0130           DADIN(4)=DAD(4)                                               00047830
ISN 0131           DADIN(5)=DAD(5)                                               00047840
ISN 0132           DADIN(6)=DAD(6)                                               00047850
                C                                                                  00047860
                C     DEFINE GODDARD EARTH CONSTANTS                               00047870
                C                                                                  00047880
ISN 0133           GM=3.986032D+5                                                00047890
ISN 0134           FJ2=1.0823D-3                                                 00047900
ISN 0135           FJ3=-2.3D-6                                                   00047910
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ISN 0136            FJ4=-1.6D-6                                                          00047920
ISN 0137            FJ5=0.0D0                                                            00047930
ISN 0138            RE=6378.165D0                                                        00047940
                C                                                                        00047950
                C                                                                        00047960
                C                                                                        00047970
                C   CARD NO. 1   RUN IDENTIFICATION CARD (CAN CONTAIN ANY DESIRED INFOR-C0047980
                C                MATION IN COLUMNS 2 THROUGH 72.)                        00047990
                C                                                                        00048000
ISN 0139         7900 READ 6002,(XHEAD(I),I=1,12)                                        00048010
ISN 0140            DTIMES = 0.D 00                                                      00048020
ISN 0141            DMIN=0.D 00                                                          00048030
ISN 0142            WRITE(6,1800)                                                        00048040
ISN 0143            WRITE(6,6002)(XHEAD(I),I=1,12)                                       00048050
                C                                                                        00048060
                C   CARD NO. 2   RUN CONTROL CARD                                       00048070
                C     COLUMNS 1-3  INPUT TYPE INDICATOR  (INPUT)                         00048080
                C                  +01 = OSCULATING ELEMENTS                             00048090
                C                  +03 = INERTIAL POSITION AND VELOCITY                  00048100
                C                  +04 = BROUWER MEAN ELEMENTS                           00048110
                C     COLUMNS 4-6  SOURCE OF EARTH CONSTANTS INDICATOR  (NCST)          00048120
                C                  ANY POSITIVE INTEGER = EARTH CONSTANTS TO BE READ FROM 00048130
                C                                         CARDS 4 AND 5.                 00048140
                C                  ANY NEGATIVE INTEGER OR ZERO : OMIT CARDS 4 AND 5      00048150
                C                                                 THE FOLLOWING CONSTANTS 00048160
                C                                                 ARE USED:              00048170
                C                                      0 = GODDARD EARTH CONSTANTS ARE   00048180
                C                                          BEING USED.                   00048190
                C          GM =3.98603200D+05((KM CUBED)/(SECONDS SQUARED))            00048200
                C          R = 6378.165 KM                                             00048210
                C J2=+1.08230D-03    J3=-2.300D-06                                     00048220
                C J4=-1.800D-06      J5= 0.0                                           00048230
                C                                     -1 = EARTH CONSTANTS OF THE SIRY   00048240
                C                                          PACKAGE ARE BEING USED.       00048250
                C          GM =3.9862688CD+05((KM CUBED)/(SECONDS SQUARED))            00048260
                C          R = 6378.388 KM                                             00048270
                C J2=+1.C8219D-03    J3=-2.285D-06                                     00048280
                C J4=-2.123D-06      J5=-2.32D-07                                      00048290
                C                                     -2 = GODDARD EARTH CONSTANTS WITH  00048300
                C                                          HARMONICS = ZERO ARE BEING USED.00048310
                C          GM =3.9860320CD+05((KM CUBED)/(SECONDS SQUARED))            00048320
                C          R = 6378.165 KM                                             00048330
                C                                     -3 = INTERNATIONAL EARTH CONSTANTS 00048340
                C                                          WITH HARMONICS = ZERO ARE BEING 00048350
                C                                          USED.                         00048360
                C          GM =3.98626873D+05((KM CUBED)/(SECONDS SQUARED))            00048370
                C          R = 6378.388 KM                                             00048380
ISN 0144         1005 CONTINUE                                                          00048390
                C     COLUMNS 7-9  INDICATOR OF SOURCE FOR TOLERANCE AND MAXIMUM NUMBER 00048400
                C                  OF ITERATIONS ALLOWED IN SOLVING KEPLER'S EQUATION  00048410
                C                  (NERR).                                             00048420
                C                  TOLERANCE IS UPPER LIMIT OF (E2-E1)/E2,WHERE E1 AND 00048430
                C                  E2 ARE VALUES OF THE ECCENTRIC ANOMALY IN TWO SUCCES-00048440
                C                  SIVE ITERATIONS.                                    00048450
                C                ANY POSITIVE INTEGER = READ TOLERANCE AND MAXIMUM NUM- 00048460
                C                                       BER OF ITERATIONS ALLOWED IN SO-00048470
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C                                       LUTION OF KEPLER'S EQUATION FROM00048480
C                                       CARD 3.                         00048490
C               ANY NEGATIVE INTEGER                                    00048500
C               OR 0                = OMIT CARD 3. TOLERANCE FOR EC-    00048510
C                                       CENTRIC ANOMALY IS .10D-13 AND  00048520
C                                       THE MAXIMUM NUMBER OF ITERATIONS00048530
C                                       IS 50.                          00048540
C     COLUMNS 10-12  BROUWER TRUNCATION INDICATOR IN SUBROUTINE BBRWR   00048550
C                    (NDA).                                             00048560
C     ANY POSITIVE                                                      00048570
C     INTEGER      = READ TOLERANCES TO BE USED IN DETERMINING MEAN     00048580
C                    BROUWER ELEMENTS FROM CARD 6.                      00048590
C               ANY NEGATIVE                                            00048600
C               INTEGER OR 0 = OMIT CARD 6. THE FOLLOWING TOLERANCES    00048610
C                              ARE USED IN DETERMINING BROUWER MEAN     00048620
C                              ELEMENTS.                                00048630
C                                SEMIMAJOR AXIS       = .50D-10 KM      00048640
C                                ECCENTRICITY         = .50D-14         00048650
C                                INCLINATION          = .50D-11 DEGREES 00048660
C                RIGHT ASCENSION OF ASCENDING NODE    = .50D-11 DEGREES 00048670
C                                ARGUMENT OF PERIGEE  = .50D-11 DEGREES 00048680
C                                MEAN ANOMALY         = .50D-11 DEGREES 00048690
ISN 0145       7001 CONTINUE                                            00048700
C     COLUMNS 13-15  MAXIMUM NUMBER OF ITERATIONS ALLOWED IN DETERMINING00048710
C                    BROUWER MEAN ELEMENTS(IRC).                        00048720
C     COLUMNS 16-18  TYPE OF UNITS USED ON CARDS 8A-8H(NUNIT).          00048730
C                 0 = UNIT  OF LENGTH = MEGAMETERS,UNIT OF TIME = HOUR, 00048740
C                     ANGLES IN DEGREES                                 00048750
C                     COEFFICIENTS OF LINEAR TERMS ARE GIVEN PER HOUR   00048760
C                     COEFFICIENTS OF QUADRATIC TERMS ARE GIVEN PER     00048770
C                     ( 100 HOURS ) SQUARED                             00048780
C                     COEFFICIENTS OF CUBIC      TERMS ARE GIVEN PER    00048790
C                     ( 100 HOURS ) CUBED.                              00048800
C                 OTHER THAN 0 = UNIT OF LENGTH = EARTH'S RADIUS,UNIT OF 00048810
C                     TIME = CUT, ANGLES IN RADIANS.                    00048820
C                     (VANGUARD UNITS)                                  00048830
C                     COEFFICIENTS OF LINEAR TERMS ARE GIVEN PER CUT    00048840
C                     COEFFICIENTS OF QUADRATIC TERMS ARE GIVEN PER     00048850
C                     ( CUT ) SQUARED.                                  00048860
C                     COEFFICIENTS OF CUBIC      TERMS ARE GIVEN PER    00048870
C                     ( CUT ) CUBED.                                    00048880
C     COLUMNS 19-21  INTERMEDIATE OUTPUT FROM SUBROUTINE BRWRI INDICATOR00048890
C                    (NBRWR1).                                          00048900
C                 0 = DO NOT PRINT INTERMEDIATE OUTPUT.                 00048910
C                 OTHER THAN 0 = PRINT INTERMEDIATE OUTPUT.             00048920
C     COLUMNS 22-24  LONG PERIOD PERTURBATIONS INDICATOR (NLONG)        00048930
C                 0 = DO NOT INCLUDE LONG PERIOD PERTURBATIONS          00048940
C                 OTHER THAN 0 = INCLUDE LONG PERIOD PERTURBATIONS      00048950
C     COLUMNS 25-27  SHORT PERIOD PERTURBATIONS INDICATOR (NSHORT)      00048960
C                 0 = DO NOT INCLUDE SHORT PERIOD PERTURBATIONS         00048970
C       ANY NEGATIVE INTEGER = THE SHORT PERIOD PERTURBATIONS ARE COM-   00048980
C                              PUTED WITH E" AND I".                     00048990
C       ANY POSITIVE INTEGER = THE SHORT PERIOD PERTURBATIONS ARE COM-   00049000
C                              PUTED WITH E' AND I'.                     00049010
ISN 0146       7002 CONTINUE                                            00049020
C     COLUMNS 28-30  SECOND ORDER SHORT-PERIOD TERMS IN SEMIMAJOR AXIS  00049030
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C                    INDICATOR (NSEC)                                          00049040
C                  0 = DO NOT INCLUDE SECOND ORDER SHORT-PERIOD TERMS.         00049050
C                  OTHER THAN 0 = INCLUDE SECOND ORDER SHORT-PERIOD TERMS.     00049060
C      COLUMNS 31-33 INTERMEDIATE OUTPUT OF SECOND ORDER SHORT-PERIOD          00049070
C                    PERTURBATIONS IN SEMIMAJOR AXIS INDICATOR (NSECD)         00049080
C                  0= DO NOT PRINT INTERMEDIATE OUTPUT.                        00049090
C                  OTHER THAN 0 = PRINT INTERMEDIATE OUTPUT.                   00049100
C         NOTE:  INTERMEDIATE DATA OUTPUT AT EPOCH WILL NOT BE PRINTED         00049110
C              UNLESS EPOCH DATE IS INCLUDED AMONG THE DATES IN REQUESTED      00049120
C              EPHEMERIDES                                                     00049130
C      COLUMNS 34-36  SUPPLEMENTARY PERTURBATIONS INDICATOR (NSUPP)            00049140
C                  0 = DO NOT INCLUDE SUPPLEMENTARY PERTURBATIONS              00049150
C                  OTHER THAN 0 = INCLUDE SUPPLEMENTARY PERTURBATIONS.         00049160
C      COLUMNS 37-39 INTERMEDIATE OUTPUT OF SUPPLEMENTARY PERTURBATIONS        00049170
C                    INDICATOR (NSUPPD)                                        00049180
C                  0= DO NOT PRINT INTERMEDIATE OUTPUT.                        00049190
C                  OTHER THAN 0 = PRINT INTERMEDIATE OUTPUT.                   00049200
C         NOTE:  INTERMEDIATE DATA OUTPUT AT EPOCH WILL NOT BE PRINTED         00049210
C              UNLESS EPOCH DATE IS INCLUDED AMONG THE DATES IN REQUESTED      00049220
C              EPHEMERIDES                                                     00049230
C      COLUMNS 40-42  MEAN MOTION INDICATOR (NKOZ)                             00049240
C                  0 = USE BROUWER'S MEAN MOTIONS.                             00049250
C                  OTHER THAN 0 = USE KOZAI'S MEAN MOTIONS.                    00049260
C      COLUMNS 43-45  INTERMEDIATE OUTPUT OF COMPUTATION OF KOZAI MEAN         00049270
C                     MOTIONS INDICATOR (NKOZD)                                00049280
C                     0 = DO NOT PRINT INTERMEDIATE OUTPUT.                    00049290
C                     OTHER THAN 0 = PRINT INTERMEDIATE OUTPUT.                00049300
ISN 0147        READ 6003,INPUT,      NCST,NERR,NDA,IRC,        NUNIT,NBRWR1,  00049310
               1NLONG,NSHORT,NSEC,NSECD,NSUPP,NSUPPD,NKOZ,NKOZD                 00049320
ISN 0148        WRITE(6,1800)                                                   00049330
ISN 0149        WRITE(6,1852)                                                   00049340
ISN 0150        WRITE(6,1851)INPUT,      NCST,NERR,NDA,IRC,        NUNIT,NBRWR100049350
               1,NLONG,NSHORT,NSEC,NSECD,NSUPP,NSUPPD,NKOZ,NKOZD                00049360
ISN 0151        NSECE=NSECD                                                     00049370
ISN 0152        NSUPPE=NSUPPD                                                   00049380
ISN 0153        NSECD=0                                                         00049390
ISN 0154        NSUPPD=0                                                        00049400
ISN 0155     5034 IF (INPUT)300,300,2                                           00049410
C       IF INPUT=+00 OR -XX, ALL CASES HAVE BEEN RUN.  GO TO 300 (END           00049420
C                                                                               00049430
C       TEST - CHANGE TRUNCATION FACTOR - YES OR NO                             00049440
C                                                                               00049450
ISN 0156        2 IF (NERR)4,4,3                                                00049460
C                                                                               00049470
C    CARD NO. 3   TOLERANCE AND MAXIMUM NUMBER OF ITERATIONS ALLOWED IN         00049480
C                 SOLVING KEPLER'S EQUATION.                                    00049490
C                   TOLERANCE IS UPPER LIMIT OF (E2-E1)/E2,WHERE E1 AND         00049500
C                   E2 ARE VALUES OF THE ECCENTRIC ANOMALY IN TWO SUCCES-       00049510
C                   SIVE ITERATIONS.                                            00049520
C                                                                               00049530
C              NOTE: THIS CARD IS REQUIRED IF AND ONLY IF COLUMNS 7-9           00049540
C              OF CARD 2(RUN CONTROL CARD) CONTAIN A POSITIVE INTEGER.          00049550
C                                                                               00049560
C       COLUMNS 1- 8 ECCENTRIC ANOMALY TOLERANCE IN FORMAT D8.2.                00049570
C       COLUMNS 9-12 MAXIMUM NO OF ITERATIONS ALLOWED IN SOLUTION OF KEP-       00049580
C                    LER'S EQUATION.                                            00049590
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                C                                                                       00049600
ISN 0157            3 READ 6040,ERR,NMAX                                                00049610
                C   CARDS NO. 4 AND 5  EARTH CONSTANTS CARDS                           00049620
                C                                                                       00049630
                C             NOTE: THESE CARDS ARE REQUIRED IF AND ONLY IF COLUMNS 4-6 00049640
                C                   OF CARD NO. 2 (THE RUN CONTROL CARD) CONTAIN  A     00049650
                C                   POSITIVE INTEGER.                                   00049660
                C                                                                       00049670
                C                                                                       00049680
                C          FOR CARD 4                                                   00049690
                C     COLUMNS  1-12 CONSTANT OF ATTRACTION IN (KM CUBED / SEC SQUARED)  00049700
                C     COLUMNS 13-24  J2 )                                               00049710
                C     COLUMNS 25-36  J3  ) COEFFICIENTS OF ZONAL HARMONICS              00049720
                C     COLUMNS 37-48  J4  ) OF DEGREES 2-5                               00049730
                C     COLUMNS 49-60  J5 )                                               00049740
                C     FORMAT IS D12.6,4D12.5                                            00049750
                C                                                                       00049760
                C          FOR CARD 5                                                   00049770
                C     COLUMNS 1-24 MEAN EQUATORIAL RADIUS OF THE EARTH IN MEGAMETERS    00049780
                C               FORMAT IS D24.17                                        00049790
ISN 0158            4 IF (NCST)5,11,10                                                  00049800
                C                                                                       00049810
                C     TO NEXT STEP.                                                     00049820
                C                                                                       00049830
ISN 0159            5 IF (NCST+1)7,6,7                                                  00049840
                C                                                                       00049850
                C     USE SIRY PACKAGE CONSTANTS IF NCST = -1                           00049860
                C                                                                       00049870
ISN 0160             6    GM=3.9862688D+05                                              00049880
ISN 0161                  FJ2=1.08219D-03                                               00049890
ISN 0162                  FJ3=-2.285E-06                                                00049900
ISN 0163                  FJ4=-2.123D-06                                                00049910
ISN 0164                  FJ5=-2.32D-07                                                 00049920
ISN 0165                  RE=6378.388D0                                                 00049930
ISN 0166                  GO TO 11                                                      00049940
ISN 0167            7 IF (NCST+2)9,8,11                                                 00049950
                C                                                                       00049960
                C     USE GODDARD EARTH CONSTANTS WITH HARMONICS =0 IF NCST = -2       00049970
                C                                                                       00049980
ISN 0168             8    FJ2=0.0D0                                                     00049990
ISN 0169                  FJ3=0.0D0                                                     00050000
ISN 0170                  FJ4=0.0D0                                                     00050010
ISN 0171                  FJ5=0.0D0                                                     00050020
ISN 0172                  GO TO 11                                                      00050030
                C                                                                       00050040
                C     USE INTERNATIONAL CONSTANTS WITH HARMONICS = 0 IF NCST = -3       00050050
                C                                                                       00050060
ISN 0173             9    GM=3.98626873D+5                                              00050070
ISN 0174                  FJ2=0.0D0                                                     00050080
ISN 0175                  FJ3=0.0D0                                                     00050090
ISN 0176                  FJ4=0.0D0                                                     00050100
ISN 0177                  FJ5=0.0D0                                                     00050110
ISN 0178                  RE=6378.388D0                                                 00050120
ISN 0179                  GO TO 11                                                      00050130
                C                                                                       00050140
                C                                                                       00050150
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                C                                                                       00050160
                C                                  IF NCST=+XX.                         00050170
                C                                                                       00050180
ISN 0180           10 READ 6004,GM,FJ2,FJ3,FJ4,FJ5,   REM                              00050190
ISN 0181           RE=1.D 03*REM                                                        00050200
ISN 0182           REML = REM                                                           00050210
                C                                                                       00050220
                C     CONVERT EARTH CONSTANTS                                           00050230
                C                                                                       00050240
ISN 0183           11 GP(1)=GM                                                          00050250
ISN 0184           GP(2)=.5D 0*FJ2*RE**2                                                00050260
ISN 0185           GP(3)=-FJ3*RE**3                                                     00050270
ISN 0186           GP(4)=-.375D0*FJ4*RE**4                                              00050280
ISN 0187           GP(5)=-FJ5*RE**5                                                     00050290
ISN 0188           CJ2S=FJ2**2                                                          00050300
ISN 0189           CJ3=FJ3                                                              00050310
ISN 0190           CJ4=FJ4                                                              00050320
                C                                                                       00050330
                C     COMPUTE K AND CANONICAL UNIT                                      00050340
ISN 0191           CON1=GM*1.0D-09*(8.64D 04)**2                                        00050350
ISN 0192           REC=RE*1.D 05                                                        00050360
ISN 0193           GE=GM*1.D 15                                                         00050370
ISN 0194           FK=6.48D 00*1.D-07*DSQRT(GE)/PI                                      00050380
ISN 0195           CMU=1.D 00                                                           00050390
ISN 0196           TUS=(DSQRT(REC))**3/DSQRT(GE)                                        00050400
ISN 0197           TUH=TUS/3.6D 03                                                      00050410
ISN 0198           CON2=(1.D 03/RE)*TUH                                                 00050420
ISN 0199           WRITE(6,1800)                                                        00050430
ISN 0200           WRITE(6,1857)                                                        00050440
ISN 0201           WRITE(6,1880)REM,CON2                                                00050450
ISN 0202           WRITE(6,1800)                                                        00050460
ISN 0203           WRITE(6,1827)CON1                                                    00050470
ISN 0204           WRITE(6,1823)FK                                                      00050480
ISN 0205           WRITE(6,1822)TUS,TUH                                                 00050490
ISN 0206           WRITE(6,1854)                                                        00050500
ISN 0207           PRINT 6005,       RE,   GM,FJ2,FJ3,FJ4,FJ5                           00050510
ISN 0208         913 IF (NLA)915,915,914                                                00050520
                C                                                                       00050530
                C   CARD NO. 6  BROUWER MEAN ELEMENTS TOLERANCE CARD                    00050540
                C              NOTE:THIS CARD IS REQUIRED IF AND ONLY IF COLUMNS 10-12  00050550
                C              OF CARD NO. 2(THE RUN CONTROL CARD) CONTAIN A POSITIVE   00050560
                C              INTEGER.                                                 00050570
                C     COLUMNS  1- 8 TOLERANCE FOR SEMIMAJOR AXIS IN MEGAMETERS          00050580
                C     COLUMNS  9-16 TOLERANCE FOR ECCENTRICITY                          00050590
                C     COLUMNS 17-24 TOLERANCE FOR INCLINATION IN DEGREES                00050600
                C     COLUMNS 25-32 TOLERANCE FOR RIGHT ASCENSION OF ASCENDING NODE IN  00050610
                C                                 DEGREES                               00050620
                C     COLUMNS 33-40 TOLERANCE FOR ARGUMENT OF PERIGEE IN DEGREES        00050630
                C     COLUMNS 41-48 TOLERANCE FOR MEAN ANOMALY IN DEGREES               00050640
                C              FORMAT IS 6D8.2                                          00050650
                C                                                                       00050660
ISN 0209         914 READ 6050,(DAD(N),N=1,6)                                           00050670
ISN 0210           DO 9141 N=1,6                                                        00050680
ISN 0211        9141 DADIN(N)=DAD(N)                                                    00050690
ISN 0212           DAD(1)=DAD(1)*1.D 03                                                 00050700
ISN 0213         915 DA(1)=DAD(1)                                                       00050710
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ISN 0214            DA(2)=DAD(2)                                                        00050720
ISN 0215            DO 916 N=3,6                                                        00050730
ISN 0216          916 DA(N)=DAD(N)*0.017453292D0                                        00050740
ISN 0217            IF (IRC)917,917,918                                                 00050750
ISN 0218          917 IRC=50                                                            00050760
                C   CARD NO. 7  ORBIT,OBJECT AND EPOCH CARD                            00050770
                C     COLUMNS  1- 3 ORBIT NUMBER                                      00050780
                C     COLUMNS  4-11 OBJECT + ORBIT NUMBER (ORBIT NUMBER IS DECIMAL POR- 00050790
                C                   TION TO 0.001)                                    00050800
                C     COLUMNS 12-13 LAST TWO DIGITS OF YEAR                           00050810
                C     COLUMNS 14-15 MONTH                                             00050820
                C     COLUMNS 16-17 DAY                                               00050830
                C     COLUMN  18    BLANK                                             00050840
                C     COLUMNS 19-20 HOUR                                              00050850
                C     COLUMNS 21-22 MINUTES                                           00050860
                C     COLUMNS 23    BLANK                                             00050870
                C     COLUMNS 24-27 SECONDS TO HUNDREDTHS OF SECONDS. NO DECIMAL POINT. 00050880
                C                                                                     00050890
                C   CARDS NO. 8A THROUGH 8H (8 CARDS)                                 00050900
                C     UNITS ARE DEFINED BY QUANTITY IN COLUMNS 16-18 OF CARD NO.2(THE  00050910
                C     RUN CONTROL CARD).                                              00050920
                C     THE FORMAT OF EACH OF CARDS 8A-8H IS 3D24.17.                   00050930
                C                                                                     00050940
                C                 A = SEMIMAJOR AXIS                                  00050950
                C                 E = ECCENTRICITY                                    00050960
                C                 I  =  INCLINATION TO THE EQUATOR                    00060970
                C                 NODE = RIGHT ASCENSION OF ASCENDING NODE            00050980
                C                 OMEGA = ARGUMENT OF PERIGEE                         00050990
                C                 M = MEAN ANOMALY                                    00051000
                C                                                                     00051010
                C                                                                     00051020
                C     CARD 8A (COLUMNS 1-3 OF CARD 2 CONTAIN EITHER +01 OR +04)       00051030
                C         COLUMNS  1-24 OSCULATING (+01) OR BROUWER MEAN (+04) A      00051040
                C         COLUMNS 25-48 OSCULATING (+01) OR BROUWER MEAN (+04) E      00051050
                C         COLUMNS 49-72 OSCULATING (+01) OR BROUWER MEAN (+04) I      00051060
                C                                                                     00051070
                C     CARD 8B (COLUMNS 1-3 OF CARD 2 CONTAIN EITHER +01 OR +04 )      00051080
                C         COLUMNS  1-24 OSCULATING (+01) OR BROUWER MEAN (+04) NODE   00051090
                C         COLUMNS 25-48 OSCULATING (+01) OR BROUWER MEAN (+04) OMEGA  00051100
                C         COLUMNS 49-72 OSCULATING (+01) OR BROUWER MEAN (+04) M      00051110
                C         NOTE: THESE COMPONENTS ARE AT EPOCH REFERRED TO THE EQUATOR  00051120
                C               AND EQUINOX.                                          00051130
                C                                                                     00051140
                C                                                                     00051150
                C                                                                     00051160
                C     CARD 8A (COLUMNS 1-3 OF CARD 2 CONTAIN +03)                     00051170
                C         COLUMNS  1-24 X COMPONENT OF POSITION VECTOR                00051180
                C         COLUMNS 25-48 Y COMPONENT OF POSITION VECTOR                00051190
                C         COLUMNS 49-72 Z COMPONENT OF POSITION VECTOR                00051200
                C                                                                     00051210
ISN 0219         1011 CONTINUE                                                        00051220
                C     CARD 8B (COLUMNS 1-3 OF CARD 2 CONTAIN +03)                     00051230
                C         COLUMNS  1-24 X COMPONENT OF VELOCITY VECTOR                00051240
                C                 25-48 Y COMPONENT OF VELOCITY VECTOR                00051250
                C                 49-72 Z COMPONENT OF VELOCITY VECTOR                00051260
                C         NOTE: THESE COMPONENTS ARE AT EPOCH REFERRED TO THE EQUATOR  00051270
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C                AND EQUINOX.                                                    00051280
C                                                                                00051290
C                                                                                00051300
C                                                                                00051310
C                                                                                00051320
C                                                                                00051330
C                                                                                00051340
C                                                                                00051350
C     FOR ALL VALUES IN COLUMNS 1-3 OF CARD 2:                                   00051360
C     CARD 8C                                                                    00051370
C         COLUMNS  1-24 COEFFICIENT OF LINEAR TERM IN A                          00051380
C         COLUMNS 25-48 COEFFICIENT OF LINEAR TERM IN E                          00051390
C         COLUMNS 49-72 COEFFICIENT OF LINEAR TERM IN I                          00051400
C                                                                                00051410
C     CARD 8D                                                                    00051420
C         COLUMNS  1-24 COEFFICIENT OF ADDITIONAL LINEAR TERM  IN NODE           00051430
C         COLUMNS 25-48 COEFFICIENT OF ADDITIONAL LINEAR TERM  IN OMEGA          00051440
C         COLUMNS 49-72 COEFFICIENT OF ADDITIONAL LINEAR TERM  IN M              00051450
C                                                                                00051460
C     CARD 8E                                                                    00051470
C         COLUMNS  1-24 COEFFICIENT OF QUADRATIC TERM  IN A                      00051480
C         COLUMNS 25-48 COEFFICIENT OF QUADRATIC TERM  IN E                      00051490
C         COLUMNS 49-72 COEFFICIENT OF QUADRATIC TERM  IN I                      00051500
C                                                                                00051510
C     CARD 8F                                                                    00051520
C         COLUMNS  1-24 COEFFICIENT OF QUADRATIC TERM  IN NODE                   00051530
C         COLUMNS 25-48 COEFFICIENT OF QUADRATIC TERM  IN OMEGA                  00051540
C         COLUMNS 49-72 COEFFICIENT OF QUADRATIC TERM  IN M                      00051550
C                                                                                00051560
C     CARD 8G                                                                    00051570
C         COLUMNS  1-24 COEFFICIENT OF CUBIC TERM  IN A                          00051580
C         COLUMNS 25-48 COEFFICIENT OF CUBIC TERM  IN E                          00051590
C         COLUMNS 49-72 COEFFICIENT OF CUBIC TERM  IN I                          00051600
C                                                                                00051610
C     CARD 8H                                                                    00051620
C         COLUMNS  1-24 COEFFICIENT OF CUBIC TERM  IN NODE                       00051630
C         COLUMNS 25-48 COEFFICIENT OF CUBIC TERM  IN OMEGA                      00051640
C         COLUMNS 49-72 COEFFICIENT OF CUBIC TERM  IN M                          00051650
C                                                                                00051660
ISN 0220    918 READ 6006,NCASE,CASE,NYE,NME,NDE,NHE,NMNE,TSE,  (AINPUT(N),N=1,24)00051670
ISN 0221        DO 421 I =1,12                                                   00051680
ISN 0222    421 JA(I) = 0                                                        00051690
ISN 0223        ORB1 = 0.D 00                                                    00051700
ISN 0224        ORB2=0.D 00                                                      00051710
ISN 0225        WRITE (21,3999)NCASE,CASE,(JA(I),I=1,12),ORB1,ORB2               00051720
ISN 0226        NYE=1900+NYE                                                     00051730
C                                                                                00051740
C     CONVERT EPOCH CALENDAR DATE TO EPOCH JULIAN DATE AT 0 HOURS                00051750
C     UNIVERSAL TIME.                                                            00051760
C                                                                                00051770
ISN 0227        DJ0=DJUL(NME,NDE,NYE)                                            00051780
C                                                                                00051790
C                                                                                00051800
C     CONVERT EPOCH UNIVERSAL TIME IN HOURS, MINUTES, AND SECONDS                00051810
C     TO SECONDS.                                                                00051820
C                                                                                00051830
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ISN 0228            THE=NHE*3600                                                    00051840
ISN 0229            TMNE=NMNE*60                                                    00051850
ISN 0230            TSEP=THE+TMNE+TSE                                               00051860
ISN 0231            DJL=DJ0+(TSEP/8.64D 04)                                         00051870
ISN 0232            IF(NSUPP)9181,9182,9181                                         00051880
                C   READ CARDS 8I,8J,..... FROM SR SUPPO                            00051890
ISN 0233     9181   CALL SUPPO                                                      00051900
ISN 0234            IF(NARG)9183,9183,9184                                          00051910
ISN 0235     9183   WRITE(6,1886)NARG                                               00051920
ISN 0236            STOP                                                            00051930
ISN 0237     9184   IF(NARG-99)9182,9182,9183                                       00051940
ISN 0238     9182   WRITE(6,1831)                                                   00051950
ISN 0239            WRITE(6,1882)CASE                                               00051960
ISN 0240            WRITE(6,6010)DJL,NYE,NME,NDE,NHE,NMNE,TSE                       00051970
ISN 0241            GO TO (8210,8220,8220,8230),INPUT                               00051980
ISN 0242     8210   IF(NUNIT)8212,8211,8212                                         00051990
ISN 0243     8211   WRITE(6,1836)(AINPUT(I),I=1,6)                                  00052000
ISN 0244            GO TO 8250                                                      00052010
ISN 0245     8212   WRITE(6,1837)(AINPUT(I),I=1,6)                                  00052020
ISN 0246            GO TO 8250                                                      00052030
ISN 0247     8220   IF(NUNIT)8222,8221,8222                                         00052040
ISN 0248     8221   WRITE(6,1832)(AINPUT(I),I=1,6)                                  00052050
ISN 0249            GO TO 8250                                                      00052060
ISN 0250     8222   WRITE(6,1833)(AINPUT(I),I=1,6)                                  00052070
ISN 0251            GO TO 8250                                                      00052080
ISN 0252     8230   IF(NUNIT)8232,8231,8232                                         00052090
ISN 0253     8231   WRITE(6,1834)(AINPUT(I),I=1,6)                                  00052100
ISN 0254            GO TO 8250                                                      00052110
ISN 0255     8232   WRITE(6,1835)(AINPUT(I),I=1,6)                                  00052120
ISN 0256     8250   IF(NUNIT)8252,8251,8252                                         00052130
ISN 0257     8251   WRITE(6,1838)(AINPUT(I),I=7,12)                                 00052140
ISN 0258            WRITE(6,1840)(AINPUT(I),I=13,18)                                00052150
ISN 0259            WRITE(6,1842)(AINPUT(I),I=19,24)                                00052160
ISN 0260            GO TO 8260                                                      00052170
ISN 0261     8252   WRITE(6,1839)(AINPUT(I),I=7,12)                                 00052180
ISN 0262            WRITE(6,1841)(AINPUT(I),I=13,18)                                00052190
ISN 0263            WRITE(6,1843)(AINPUT(I),I=19,24)                                00052200
ISN 0264     8260   CONTINUE                                                        00052210
ISN 0265            IF(NUNIT)8100,8110,8100                                         00052220
                C                                                                   00052230
                C   IF ELEMENTS ARE INPUT INDICES 4,10,16,22 ARE CHANGED TO REFER TO 00052240
                C   MEAN ANOMALY AND 6,12,18,24 TO NODE                            00052250
                C                                                                   00052260
ISN 0266     8100   GO TO(8101,8103,8102,8101),INPUT                                00052270
ISN 0267     8101   DO 8104 I=1,24                                                  00052280
ISN 0268     8104   AI(I)=AINPUT(I)                                                 00052290
ISN 0269            AI( 4)=AINPUT( 6)                                               00052300
ISN 0270            AI( 6)=AINPUT( 4)                                               00052310
ISN 0271            AI(10)=AINPUT(12)                                               00052320
ISN 0272            AI(12)=AINPUT(10)                                               00052330
ISN 0273            AI(16)=AINPUT(18)                                               00052340
ISN 0274            AI(18)=AINPUT(16)                                               00052350
ISN 0275            AI(22)=AINPUT(24)                                               00052360
ISN 0276            AI(24)=AINPUT(22)                                               00052370
ISN 0277            AIDH( 1)=AINPUT( 1)*REM                                         00052380
ISN 0278            AIDH( 2)=AINPUT( 2)                                             00052390
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ISN 0279           AIDH( 3)=AINPUT( 3)*CONV                                    00052400
ISN 0280           AIDH( 4)=AINPUT( 4)*CONV                                    00052410
ISN 0281           AIDH( 5)=AINPUT( 5) *CONV                                   00052420
ISN 0282           AIDH( 6)=AINPUT( 6)*CONV                                    00052430
ISN 0283      8107 AIDH( 7)=AINPUT( 7)*REM/TUH                                 00052440
ISN 0284           AIDH( 8)=AINPUT( 8)/TUH                                     00052450
ISN 0285           AIDH( 9)=AINPUT( 9)*CONV/TUH                                00052460
ISN 0286           AIDH(10)=AINPUT(10)*CONV/TUH                                00052470
ISN 0287           AIDH(11)=AINPUT(11)*CONV/TUH                                00052480
ISN 0288           AIDH(12)=AINPUT(12)*CONV/TUH                                00052490
ISN 0289           AIDH(13)=AINPUT(13)*REM*1.D 04/TUH**2                       00052500
ISN 0290           AIDH(14)=AINPUT(14)*1.D 04/TUH**2                           00052510
ISN 0291           AIDH(15)=AINPUT(15)*CONV*1.D 04/TUH**2                      00052520
ISN 0292           AIDH(16)=AINPUT(16)*CONV*1.D 04/TUH**2                      00052530
ISN 0293           AIDH(17)=AINPUT(17)*CONV*1.D 04/TUH**2                      00052540
ISN 0294           AIDH(18)=AINPUT(18)*CONV*1.D 04/TUH**2                      00052550
ISN 0295           AIDH(19)=AINPUT(19)*REM*1.D 06/TUH**3                       00052560
ISN 0296           AIDH(20)=AINPUT(20)*1.D 06/TUH**3                           00052570
ISN 0297           AIDH(21)=AINPUT(21)*CONV*1.D 06/TUH**3                      00052580
ISN 0298           AIDH(22)=AINPUT(22)*CONV*1.D 06/TUH**3                      00052590
ISN 0299           AIDH(23)=AINPUT(22)*CONV*1.D 06/TUH**3                      00052600
ISN 0300           AIDH(24)=AINPUT(24)*CONV*1.D 06/TUH**3                      00052610
ISN 0301           GO TO 8120                                                  00052620
ISN 0302      8102 DO 8103 I=1,24                                              00052630
ISN 0303      8103 AI(I)=AINPUT(I)                                             00052640
ISN 0304           AI(10)=AINPUT(12)                                           00052650
ISN 0305           AI(12)=AINPUT(10)                                           00052660
ISN 0306           AI(16)=AINPUT(18)                                           00052670
ISN 0307           AI(18)=AINPUT(16)                                           00052680
ISN 0308           AI(22)=AINPUT(24)                                           00052690
ISN 0309           AI(24)=AINPUT(22)                                           00052700
ISN 0310           AIDH( 1)=AINPUT( 1)*REM                                     00052710
ISN 0311           AIDH( 2)=AINPUT( 2)*REM                                     00052720
ISN 0312           AIDH( 3)=AINPUT( 3)*REM                                     00052730
ISN 0313           AIDH( 4)=AINPUT( 4)*REM/TUH                                 00052740
ISN 0314           AIDH( 5)=AINPUT( 5)*REM/TUH                                 00052750
ISN 0315           AIDH( 6)=AINPUT( 6)*REM/TUH                                 00052760
ISN 0316           GO TO 8107                                                  00052770
ISN 0317      8110 GO TO(8111,8112,8112,8111),INPUT                            00052780
ISN 0318      8111 DO 8114 I=1,24                                              00052790
ISN 0319      8114 AIDH(I)=AINPUT(I)                                           00052800
ISN 0320           AI( 1)=AINPUT( 1)/REM                                       00052810
ISN 0321           AI( 2)=AINPUT( 2)                                           00052820
ISN 0322           AI( 3)=AINPUT( 3) /CONV                                     00052830
ISN 0323           AI( 4)=AINPUT( 6)/CONV                                      00052840
ISN 0324           AI( 5)=AINPUT( 5)/CONV                                      00052850
ISN 0325           AI( 6)=AINPUT( 4)/CONV                                      00052860
ISN 0326      8121 AI( 7)=AINPUT( 7)*TUH/REM                                   00052870
ISN 0327           AI( 8)=AINPUT( 8)*TUH                                       00052880
ISN 0328           AI( 9)=AINPUT( 9)*TUH/CONV                                  00052890
ISN 0329           AI(10)=AINPUT(12)*TUH/CONV                                  00052900
ISN 0330           AI(11)=AINPUT(11)*TUH/CONV                                  00052910
ISN 0331           AI(12)=AINPUT(10)*TUH/CONV                                  00052920
ISN 0332           AI(13)=AINPUT(13)*TUH**2*1.D-04/REM                         00052930
ISN 0333           AI(14)=AINPUT(14)*TUH**2*1.D-04                             00052940
ISN 0334           AI(15)=AINPUT(15)*TUH**2*1.D-04/CONV                        00052950
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ISN 0335            AI(16)=AINPUT(18)*TUH**2*1.D-04/CONV                                00052960
ISN 0336            AI(17)=AINPUT(17)*TUH**2*1.D-04/CONV                                00052970
ISN 0337            AI(18)=AINPUT(16)*TUH**2*1.D-04/CONV                                00052980
ISN 0338            AI(19)=AINPUT(19)*TUH**3*1.D-06/REM                                 00052990
ISN 0339            AI(20)=AINPUT(20)*TUH**3*1.D-06                                     00053000
ISN 0340            AI(21)=AINPUT(21)*TUH**3*1.D-06/CONV                                00053010
ISN 0341            AI(22)=AINPUT(24)*TUH**3*1.D-06/CONV                                00053020
ISN 0342            AI(23)=AINPUT(23)*TUH**3*1.D-06/CONV                                00053030
ISN 0343            AI(24)=AINPUT(22)*TUH**3*1.D-06/CONV                                00053040
ISN 0344            GO TO 8120                                                          00053050
ISN 0345       8112 DO 8113 I=1,24                                                      00053060
ISN 0346       8113 AIDH(I)=AINPUT(I)                                                   00053070
ISN 0347            DO 8116 I=1,3                                                       00053080
ISN 0348            AI(I)=AINPUT(I)/REM                                                 00053090
ISN 0349       8116 AI(I+3)=AINPUT(I+2)*TUH/REM                                         00053100
ISN 0350            GO TO 8121                                                          00053110
ISN 0351       8120 NYE19=NYE-1900                                                      00053120
ISN 0352            WRITE(6,1858)                                                       00053130
ISN 0353            WRITE(6,1882)CASE                                                   00053140
ISN 0354            WRITE(6,60101DJL,NYE,NME,NDE,NHE,NMNE,TSE                           00053150
ISN 0355            GO TO (9210,9220,9220,9230),INPUT                                   00053160
ISN 0356       9210 IF(NUNIT)9211,9212,9211                                             00053170
ISN 0357       9211 WRITE(6,1836)(AIDH  (I),I=1,6)                                      00053180
ISN 0358            GO TO 9250                                                          00053190
ISN 0359       9212 WRITE(6,1837)AI(1),AI(2),AI(3),AI(6),AI(5),AI(4)                    00053200
ISN 0360            GO TO 9250                                                          00053210
ISN 0361       9220 IF(NUNIT)9222,9221,9222                                             00053220
ISN 0362       9221 WRITE(6,1833)(AI    (I),I=1,6)                                      00053230
ISN 0363            GO TO 9250                                                          00053240
ISN 0364       9222 WRITE(6,1832)(AIDH  (I),I=1,6)                                      00053250
ISN 0365            GO TO 9250                                                          00053260
ISN 0366       9230 IF(NUNIT)9232,9231,9232                                             00053270
ISN 0367       9231 WRITE(6,1835)AI(1),AI(2),AI(3),AI(6),AI(5),AI(4)                    00053280
ISN 0368            GO TO 9250                                                          00053290
ISN 0369       9232 WRITE(6,1834)(AIDH  (I),I=1,6)                                      00053300
ISN 0370       9250 IF(NUNIT)9252,9251,9252                                             00053310
ISN 0371       9251 WRITE(6,1839)AI(7),AI(8),AI(9),AI(12),AI(11),AI(10)                 00053320
ISN 0372            WRITE(6,1841)AI(13),AI(14),AI(15),AI(18),AI(17),AI(16)              00053330
ISN 0373            WRITE(6,1843)AI(19),AI(20),AI(21),AI(24),AI(23),AI(22)              00053340
ISN 0374            GO TO 9260                                                          00053350
ISN 0375       9252 WRITE(6,1838)(AIDH  (I),I=7,12)                                     00053360
ISN 0376            WRITE(6,1840)(AIDH  (I),I=13,18)                                    00053370
ISN 0377            WRITE(6,1842)(AIDH  (I),I=19,24)                                    00053380
ISN 0378       9260 CONTINUE                                                            00053390
ISN 0379            WRITE(6,1869)ERR,NMAX                                               00053400
ISN 0380            WRITE(6,1878)                                                       00053410
                 C                                                                      00053420
                 C      CONVERT EPOCH UNIVERSAL TIME IN HOURS, MINUTES, AND SECONDS   00053430
                 C      TO EPOCH UNIVERSAL TIME IN RADIANS.                           00053440
                 C                                                                      00053450
ISN 0381        2142 TIME0=HMSRZ(NHE,NMNE,TSE)                                          00053460
ISN 0382            GO TO(3002,1,28,3002) ,INPUT                                        00053470
                 C      CONVERT  TO KM AND DEGREES                                     00053480
ISN 0383        3002 AI(1)=AI(1)*RE                                                     00053490
ISN 0384            AI(3)=AI(3)*CONV                                                    00053500
ISN 0385            AAMA=AI(4)                                                          00053510
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ISN 0386            AI(4)=AI(6)*CONV                                                00053520
ISN 0387            AI(5)=AI(5)*CONV                                                00053530
ISN 0388            AI(6)=AAMA*CONV                                                 00053540
                    C                                                               00053550
                    C     CONVERT INPUT PARAMETERS TO OSCULATING ELEMENTS           00053560
                    C                                                               00053570
ISN 0389         28 CONTINUE                                                        00053580
                    C          DN = REDUCTION OF MEAN MOTION OF MEAN ANOMALY FROM BROUWER TO00053590
                    C               KOZAI IN RADIANS PER SECOND.                    00053600
ISN 0390            CALL PARA(INPUT,AI,A,GM,GDIF,NMAX,NIT,NSHORT,DN)                00053610
ISN 0391            CALL ELAV (PX,VX,E,F,RADV,A,PER,EN,GM,ERR,GDIF,NMAX,NIT)        00053620
ISN 0392            ED=E*CONV                                                       00053630
ISN 0393            FD=F*CONV                                                       00053640
ISN 0394            RADVM=RADV*1.D-03                                               00053650
ISN 0395            IF(INPUT-4)8190,8191,8190                                       00053660
                    C          DN = REDUCTION OF MEAN MOTION OF MEAN ANOMALY FROM BROUWER TO00053670
                    C               KOZAI IN RADIANS PER SECOND.                    00053680
ISN 0396         8190 CALL BERWR(DA,A,IRC,NN,GDIF,NMAX,NIT,NSHORT,DN)               00053690
ISN 0397         8191 AR=A110(1)/RE                                                 00053700
ISN 0398            DO 8099 J=1,6                                                   00053710
ISN 0399         8099 A110BR(J)=A110(J)                                             00053720
ISN 0400            A110BR(1)=A110BR(1)/1.D 03                                      00053730
ISN 0401            DO 8098 J=3,6                                                   00053740
ISN 0402         8098 A110BR(J)=A110BR(J)*CONV                                      00053750
ISN 0403            RATE(1)=0.D 00                                                  00053760
ISN 0404            RATE(2)=0.D 00                                                  00053770
ISN 0405            RATE(3)=0.D 00                                                  00053780
ISN 0406            RATE(4)=SS(3)*CONV*3.6D 03                                      00053790
ISN 0407            RATE(5)=SS(2)*CONV*3.6D 03                                      00053800
ISN 0408            RATE(6)=SS(1)*CONV*3.6D 03                                      00053810
ISN 0409            ENG=XXX(1)*CONV*3.6D 03                                         00053820
ISN 0410            RATE(7)=RATE(4)+RATE(5)                                         00053830
ISN 0411            DO 8070 I=1,7                                                   00053840
ISN 0412            DO 8070 J=1,6                                                   00053850
ISN 0413         8070 LPCOEF(I,J)=0.D 00                                            00053860
ISN 0414            LPCOEF(2,2)=EL(10)                                              00053870
ISN 0415            LPCOEF(2,4)=EL(11)                                              00053880
ISN 0416            LPCOEF(2,6)=EL(12)                                              00053890
ISN 0417            DO 8071 J=1,6                                                   00053900
ISN 0418         8071 LPCOEF(3,J)=LPCOEF(2,J)*EL(13)                                00053910
ISN 0419            LPCOEF(4,1)=EL(8)                                               00053920
ISN 0420            LPCOEF(4,3)=EL(9)                                               00053930
ISN 0421            LPCOEF(4,5)=EL(7)                                               00053940
ISN 0422            LPCOEF(5,1)=EL(5)                                               00053950
ISN 0423            LPCOEF(5,3)=EL(6)                                               00053960
ISN 0424            LPCOEF(5,5)=EL(4)                                               00053970
ISN 0425            LPCOEF(6,1)=EL(2)                                               00053980
ISN 0426            LPCOEF(6,3)=EL(3)                                               00053990
ISN 0427            LPCOEF(6,5)=EL(1)                                               00054000
ISN 0428            DO 8073 J=1,6                                                   00054010
ISN 0429         8073 LPCOEF(7,J)=LPCOFF(4,J)+LPCOEF(5,J)                           00054020
ISN 0430            DO 8072 I=3,7                                                   00054030
ISN 0431            DO 8072 J=1,6                                                   00054040
ISN 0432         8072 LPCOEF(I,J)=LPCOEF(I,J)*CONV                                  00054050
ISN 0433            WRITE(6,1800)                                                   00054060
ISN 0434            WRITE(6,1874)                                                   00054070
```

```
ISN 0435            WRITE(6,1882)CASE                                          00054080
ISN 0436            WRITE(6,6010)DJL,NYE,NME,NDE,NHE,NMNE,TSE                  00054090
ISN 0437            DN=DN*CONV*3600.D 00                                       00054100
ISN 0438            WRITE(6,1872)                                              00054110
ISN 0439            WRITE(6,1888)                                              00054120
ISN 0440            IF(NSOZ)7003,7004,7003                                     00054130
ISN 0441       7003 WRITE(6,1890)                                              00054140
ISN 0442            WRITE(6,1887)DN                                            00054150
ISN 0443            GO TO 7005                                                 00054160
ISN 0444       7004 WRITE(6,1889)                                              00054170
ISN 0445       7005 WRITE(6,1870)                                              00054180
ISN 0446            WRITE(6,1871)ENO,RATE(4),RATE(5),RATE(6),RATE(7)           00054190
ISN 0447            PAN = 3.6D 02/RATE(6)                                      00054200
ISN 0448            WRITE(6,1881)PAN                                           00054210
ISN 0449            WRITE(6,1873)                                              00054220
ISN 0450            WRITE(6,1838)(AIDH  (I),I=7,12)                            00054230
ISN 0451            WRITE(6,1840)(AIDH  (I),I=13,18)                           00054240
ISN 0452            WRITE(6,1842)(AIDH  (I),I=19,24)                           00054250
ISN 0453            WRITE(6,1830)                                              00054260
ISN 0454            WRITE(6,1830)                                              00054270
ISN 0455            WRITE(6,1810)((LPCOEF(I,J),I=1,7),J=1,3)                   00054280
ISN 0456            WRITE(6,1811)((LPCOEF(I,J),I=1,7),J=4,6)                   00054290
ISN 0457            WRITE(6,1830)                                              00054300
ISN 0458            WRITE(6,1830)                                              00054310
ISN 0459            WRITE(6,1830)                                              00054320
ISN 0460            WRITE(6,1830)                                              00054330
ISN 0461            WRITE(6,1857)                                              00054340
ISN 0462            IF(NSHORT)8074,8075,8076                                   00054350
ISN 0463       8074 WRITE(6,1883)                                              00054360
ISN 0464            GO TO 8077                                                 00054370
ISN 0465       8075 WRITE(6,1884)                                              00054380
ISN 0466            GO TO 8077                                                 00054390
ISN 0467       8076 WRITE(6,1885)                                              00054400
ISN 0468       8077 WRITE(6,1880)REM,CON2                                      00054410
ISN 0469            WRITE(6,1875)                                              00054420
ISN 0470            WRITE(6,1882)CASE                                          00054430
ISN 0471            WRITE(6,6010)DJL,NYE,NME,NDE,NHE,NMNE,TSE                  00054440
ISN 0472            WRITE(6,1859)                                              00054450
ISN 0473            WRITE(6,1819)                                              00054460
ISN 0474            WRITE(6,1816)                                              00054470
ISN 0475            WRITE(6,1860)AR,A110(2),A110(3)                            00054480
ISN 0476            WRITE(6,1860)A110(4),A110(5),A110(6)                       00054490
ISN 0477            WRITE(6,1817)                                              00054500
ISN 0478            WRITE(6,1860)(A110BR(J),J=1,3)                             00054510
ISN 0479            WRITE(6,1860)(A11CBR(J),J=4,6)                             00054520
ISN 0480            DO 8150 J=1,6                                              00054530
ISN 0481            A11BR(J)=XX(J)                                             00054540
ISN 0482            A1ER(J)=XX(J+6)                                            00054550
ISN 0483            ASHR(J)=ASHORT(J)                                          00054560
ISN 0484       8150 ABR(J)=AB(J)                                               00054570
ISN 0485            ABRR=ABR(1)/RE                                             00054580
ISN 0486            WRITE(6,1820)                                              00054590
ISN 0487            WRITE(6,1816)                                              00054600
ISN 0488            WRITE(6,1860)ABRR,ABR(2),ABR(3)                            00054610
ISN 0489            WRITE(6,1860)ABR(4),ABR(5),ABR(6)                          00054620
ISN 0490            A11BR(1)=A11BR(1)/1.D 03                                   00054630
```

```
ISN 0491            A1BR(1)=A1BR(1)/1.D 03                                    00054640
ISN 0492            ASHR(1)=ASHR  (1)/1.D 03                                  00054650
ISN 0493            ABR(1)=ABR(1)/1.D 03                                      00054660
ISN 0494            DO 8151 J=3,6                                             00054670
ISN 0495            A11BR(J)=A11BR(J)*CONV                                    00054680
ISN 0496            A1BR(J)=A1BR(J)*CONV                                      00054690
ISN 0497            ASHR(J)=ASHR  (J)*CONV                                    00054700
ISN 0498       8151 ABR(J)=ABR(J)*CONV                                        00054710
ISN 0499            WRITE(6,1817)                                             00054720
ISN 0500            WRITE(6,1860)(ABR(J),J=1,3)                               00054730
ISN 0501            WRITE(6,1860)(ABR(J),J=4,6)                               00054740
ISN 0502            DO 8152 J=1,3                                             00054750
ISN 0503            RXBM(J)=RXB(J)/1.D 03                                     00054760
ISN 0504            VXBM(J)=VXB(J)*3.6D 00                                    00054770
ISN 0505            RXBMC(J)=RXBM(J)/REM                                      00054780
ISN 0506       8152 VXBMC(J)=VXBM(J)*TUM/REM                                  00054790
ISN 0507            WRITE(6,1861)                                             00054800
ISN 0508            WRITE(6,1821)                                             00054810
ISN 0509            WRITE(6,1862)                                             00054820
ISN 0510            WRITE(6,1860)(RXBMC(J),J=1,3)                             00054830
ISN 0511            WRITE(6,1860)(VXBMC(J),J=1,3)                             00054840
ISN 0512            WRITE(6,1825)                                             00054850
ISN 0513            WRITE(6,1860)(RXBM(J),J=1,3)                              00054860
ISN 0514            WRITE(6,1860)(VXBM(J),J=1,3)                              00054870
ISN 0515            WRITE(6,1818)                                             00054880
ISN 0516            WRITE(6,1860)(RXB (J),J=1,3)                              00054890
ISN 0517            WRITE(6,1860)(VXB (J),J=1,3)                              00054900
ISN 0518            GO TO(8271,8271,8271,8272),INPUT                          00054910
ISN 0519       8271 WRITE(6,1863)                                             00054920
ISN 0520            WRITE(6,1808)                                             00054930
ISN 0521            WRITE(6,1817)                                             00054940
ISN 0522            WRITE(6,1865)(DADIN(J),J=1,6)                             00054950
ISN 0523            WRITE(6,1864)NN                                           00054960
ISN 0524            WRITE(6,1866)IRC                                          00054970
ISN 0525       8272 DO 8153 J=1,6                                             00054980
ISN 0526            DLL(J)=A1BR(J)-A11BR(J)                                   00054990
ISN 0527       8153 DLS(J)=ASHR(J)-A1BR(J)                                    00055000
ISN 0528            WRITE(6,1876)                                             00055010
ISN 0529            WRITE(6,1882)CASE                                         00055020
ISN 0530            WRITE(6,1830)                                             00055030
ISN 0531            WRITE(6,1830)                                             00055040
ISN 0532            WRITE(6,1830)                                             00055050
ISN 0533            WRITE(6,1830)                                             00055060
ISN 0534            WRITE(6,6085)DJL,NYE,NME,NDE,NHE,NMNE,TSE,DMIN            00055070
ISN 0535            WRITE(6,6083)                                             00055080
ISN 0536       8303 WRITE(6,1802)(A11ER(J),J=1,6)                             00055090
ISN 0537            WRITE(6,1803)(DLL(J),J=1,6)                               00055100
ISN 0538            WRITE(6,1804)(A1BR(J) ,    J=1,6)                         00055110
ISN 0539            WRITE(6,1806)(DLS(J),J=1,6)                               00055120
ISN 0540            WRITE(6,1848)DASUM                                        00055130
ISN 0541            WRITE(6,1849)(DSUP(J),J=1,6)                              00055140
ISN 0542            WRITE(6,1801)(ABR(J),J=1,6)                               00055150
ISN 0543            WRITE(6,1830)                                             00055160
ISN 0544            WRITE(6,1879)RADVM,ED,FD                                  00055170
ISN 0545            WRITE(6,1867)NIT                                          00055180
ISN 0546            WRITE(6,1868)GDIF                                         00055190
```

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ISN 0547          WRITE(6,1805)(RXBM(J),J=1,3),(VXBM(J),J=1,3)                    00055200
ISN 0548          WRITE(6,1855)                                                   00055210
ISN 0549          WRITE(6,1857)                                                   00055220
ISN 0550          WRITE(6,1880)REM,CON2                                           00055230
ISN 0551          VXE(1)=VX(1)                                                    00055240
ISN 0552          VXE(2)=VX(2)                                                    00055250
ISN 0553          VXE(3)=VX(3)                                                    00055260
ISN 0554          EN=SS(1)                                                        00055270
ISN 0555          DP=SS(2)                                                        00055280
ISN 0556          DN=SS(3)                                                        00055290
ISN 0557          PER=6.283185307180D0/EN                                         00055300
ISN 0558          NEPH=0                                                          00055310
                C                                                                 00055320
                C     CARD  9 READ CALENDAR DATE AND UNIVERSAL TIME AT WHICH THE START  00055330
                C             OF THE CALCULATION IS DESIRED, CALENDAR DATE AND    00055340
                C             UNIVERSAL TIME AT WHICH THE TERMINATION OF THE      00055350
                C             CALCULATION IS DESIRED, AND THE DESIRED TIME INCREMENT  00055360
                C             OF THE CALCULATION IN SECONDS.                      00055370
                C                                                                 00055380
                C     TO BE READ BY SUBROUTINE TIMC4                              00055390
                C                                                                 00055400
ISN 0559        42 NEPH=NEPH+1                                                    00055410
ISN 0560          WRITE(6,1877)NEPH                                               00055420
ISN 0561          WRITE(6,1882)CASE                                               00055430
ISN 0562          NSECD=NSECE                                                     00055440
ISN 0563          NSUPPD=NSUPPE                                                   00055450
ISN 0564          CALL TIMC4(DJ0,TSEP,XLAS,XLAF,DTLA,KPR,KLAST)                   00055460
ISN 0565          KCOUNT=0                                                        00055470
ISN 0566          IF(KPR)422,422,423                                              00055480
ISN 0567        422 KPR=1                                                         00055490
ISN 0568        423 WRITE(6,1857)                                                 00055500
ISN 0569          WRITE(6,1880)REM,CON2                                           00055510
ISN 0570          WRITE(6,1800)                                                   00055520
                C                                                                 00055530
                C     COMPUTE TIME OF DATE.                                       00055540
ISN 0571          DTIMES=XLAS-DTLA                                                00055550
ISN 0572        7016 DTIMES=DTIMES+DTLA                                           00055560
ISN 0573          DMIN=DTIMES/60.D 00                                             00055570
ISN 0574          DM=DJL+(DTIMES/8.640 04)                                        00055580
ISN 0575          DO 8059 J=1,6                                                   00055590
ISN 0576        8059 DSLP(J)=0.D 00                                               00055600
ISN 0577          TIME=TIME0+DTIMES*0.727220521664304D-4                          00055610
ISN 0578          DDJ0=IDINT(TIME/6.28318530717958600)                            00055620
ISN 0579          DJ=DJ0+      DDJ0                                               00055630
ISN 0580          TIME=ALLOT (TIME)                                               00055640
ISN 0581          II=0                                                            00055650
                C                                                                 00055660
                C     CONVERT UNIVERSAL TIME IN RADIANS TO HOURS, MINUTES, AND SECONDS  00055670
                C                                                                 00055680
ISN 0582          CALL RHMSZ(TIME-II,IH,IM,TS)                                    00055690
ISN 0583          DJ=DJ+II                                                        00055700
ISN 0584          CALL JULCAL(DJ,NM,ND,NY)                                        00055710
ISN 0585          NYM19=NY-1900                                                   00055720
                C                                                                 00055730
ISN 0586          KEF=KEF+1                                                       00055740
ISN 0587          IF(KCOUNT)8056,8057,8056                                        00055750
```

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ISN 0588      8057 WRITE(6,6085)DM,NY,NM,ND,IM,IM,TS,DMIN                          00055760
ISN 0589      8056 IF(NSHORT)8062,8062,8063                                        00055770
ISN 0590      8062 CALL BRWR2(DTIMES,     E,F,RADV,GDIF,NMAX,NIT)                  00055780
ISN 0591           GO TO 8064                                                     00055790
ISN 0592      8063 CALL BRWR4(DTIMES,     E,F,RADV,GDIF,NMAX,NIT)                  00055800
ISN 0593      8064 ED=E*CONV                                                       00055810
ISN 0594           FD=F*CONV                                                      00055820
ISN 0595           RADVM=RADV*1.D-03                                              00055830
ISN 0596           DO 8050 J=1,6                                                  00055840
ISN 0597           AGBR(J)=AG(J)                                                  00055850
ISN 0598           D1BR(J)=D1(J)                                                  00055860
ISN 0599           D2BR(J)=D2(J)                                                  00055870
ISN 0600           D3BR(J)=D3(J)                                                  00055880
ISN 0601           A11BR(J)=XX(J)                                                 00055890
ISN 0602           A1BR(J)=XX(J+6)                                                00055900
ISN 0603           ASHR(J)=ASHORT(J)                                              00055910
ISN 0604      8050 ABR(J)=AB(J)                                                   00055920
ISN 0605           AGBR(1)=AG(1)/1.D 03                                           00055930
ISN 0606           D1BR(1)=D1(1)/1.D 03                                           00055940
ISN 0607           D2BR(1)=D2(1)/1.D 03                                           00055950
ISN 0608           D3BR(1)=D3(1)/1.D 03                                           00055960
ISN 0609           A11BR(1)=A11BR(1)/1.D 03                                       00055970
ISN 0610           A1BR(1)=A1BR(1)/1.D 03                                         00055980
ISN 0611           ASHR(1)=ASHR(1)/1.D 03                                         00055990
ISN 0612           ABR(1)=ABR(1)/1.D 03                                           00056000
ISN 0613           DO 8051 J=3,6                                                  00056010
ISN 0614           AGBR(J)=AG(J)*CONV                                             00056020
ISN 0615           D1BR(J)=D1(J)*CONV                                             00056030
ISN 0616           D2BR(J)=D2(J)*CONV                                             00056040
ISN 0617           D3BR(J)=D3(J)*CONV                                             00056050
ISN 0618           A11BR(J)=A11BR(J)*CONV                                         00056060
ISN 0619           A1BR(J)=A1BR(J)*CONV                                           00056070
ISN 0620           ASHR(J)=ASHR(J)*CONV                                           00056080
ISN 0621      8051 ABR(J)=ABR(J)*CONV                                             00056090
ISN 0622           DO 8052 J=1,3                                                  00056100
ISN 0623           RXBM(J)=RXB(J)/1.D 03                                          00056110
ISN 0624      8052 VXBM(J)=VXB(J)*3.6D 00                                         00056120
ISN 0625           DO 8053 J=1,6                                                  00056130
ISN 0626           DLL(J)=A1BR(J)-A11BR(J)                                        00056140
ISN 0627      8053 DLS(J)=ASHR(J)-A1BR(J)                                         00056150
ISN 0628           IF(KCOUNT)8404,8403,8404                                       00056160
ISN 0629      8403 WRITE(6,6083)                                                  00056170
ISN 0630           WRITE(6,1844)(AGBR(J),J=1,6)                                   00056180
ISN 0631           WRITE(6,1845)(D1BR(J),J=1,6)                                   00056190
ISN 0632           WRITE(6,1846)(D2BR(J),J=1,6)                                   00056200
ISN 0633           WRITE(6,1847)(D3BR(J),J=1,6)                                   00056210
ISN 0634           WRITE(6,1802)(A11ER(J),J=1,6)                                  00056220
ISN 0635           WRITE(6,1803)(DLL(J),J=1,6)                                    00056230
ISN 0636           WRITE(6,1804)(A1BR(J) ,     J=1,6)                             00056240
ISN 0637           WRITE(6,1806)(DLS(J),J=1,6)                                    00056250
ISN 0638           WRITE(6,1848)DASUM                                             00056260
ISN 0639           WRITE(6,1849)(DSUM(J),J=1,6)                                   00056270
ISN 0640           WRITE(6,1801)(ABR(J),J=1,6)                                    00056280
ISN 0641           WRITE(6,1830)                                                  00056290
ISN 0642           WRITE(6,1879)RADVM,ED,FD                                       00056300
ISN 0643           WRITE(6,1867)INIT                                              00056310
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ISN 0644            WRITE(6,1868)GDIF                                          00056320
ISN 0645            WRITE(6,1805)(RXBM(J),J=1,3),(VXBM(J),J=1,3)               00056330
ISN 0646            WRITE(6,1830)                                              00056340
ISN 0647            WRITE(6,1830)                                              00056350
ISN 0648            WRITE(6,1830)                                              00056360
ISN 0649            WRITE(6,1830)                                              00056370
ISN 0650         8404 MMT=DTIMES/6.D 01 + 1.D-08                               00056380
ISN 0651            CALL WRT6(MMT,RXBM,VXBM,ACC,ABR,21,22,23,1,0,0)            00056390
ISN 0652            KCOUNT=KCOUNT+1                                            00056400
ISN 0653            IF(KCOUNT-KPR)8406,8405,8405                               00056410
ISN 0654         8405 KCOUNT=0                                                 00056420
ISN 0655         8406 IF(KEF-MEFL)8061,8060,8061                               00056430
ISN 0656         8060 KEF=0                                                    00056440
ISN 0657         8061 CONTINUE                                                 00056450
ISN 0658            IF (      DTIMES -XLAF)7016,7998,7998                      00056460
ISN 0659         7998 IF(KLAST)42,7999,42                                      00056470
ISN 0660         7999 END FILE 21                                              00056480
ISN 0661            GO TO 7900                                                 00056490
ISN 0662          300 PRINT 6039                                               00056500
ISN 0663            STOP                                                       00056510
ISN 0664            END                                                        00056520
```

*****F O R T R A N C R O S S R E F E R E N C E L I S T I N G*****

SYMBOL	INTERNAL STATEMENT NUMBERS																			
A	0005	0390	0391	0396																
E	0391	0392	0590	0592	0593															
F	0391	0393	0590	0592	0594															
I	0104	0105	0106	0106	0110	0111	0139	0139	0139	0143	0143	0143	0221	0222	0225	0225	0225	0243	0243	
	0243	0245	0245	0245	0248	0248	0248	0250	0250	0250	0253	0253	0253	0255	0255	0255	0257	0257	0257	
	0258	0258	0258	0259	0259	0259	0261	0261	0261	0262	0262	0262	0263	0263	0263	0267	0268	0268	0302	
	0303	0303	0318	0319	0319	0345	0346	0346	0347	0348	0348	0349	0349	0357	0357	0357	0362	0362	0362	
	0364	0364	0364	0369	0369	0369	0375	0375	0375	0376	0376	0376	0377	0377	0377	0411	0413	0430	0432	
	0432	0450	0450	0450	0451	0451	0451	0452	0452	0452	0455	0455	0455	0456	0456	0456				
J	0112	0113	0398	0399	0399	0401	0402	0402	0412	0413	0417	0418	0418	0428	0429	0429	0429	0431	0432	
	0432	0455	0455	0455	0456	0456	0456	0478	0478	0478	0479	0479	0479	0480	0481	0481	0482	0482	0483	
	0483	0484	0484	0494	0495	0495	0498	0496	0497	0497	0498	0498	0500	0500	0500	0501	0501	0501	0502	
	0503	0503	0504	0504	0505	0505	0506	0506	0510	0510	0510	0511	0511	0511	0513	0513	0513	0514	0514	
	0514	0516	0516	0516	0517	0517	0517	0522	0522	0522	0525	0526	0526	0526	052?	0527	0527	0536	0536	
	0536	0537	0537	0537	0538	0538	0538	0539	0539	0539	0541	0541	0541	0542	0542	0542	0547	0547	0547	
	0547	0547	0547	0575	0576	0596	0597	0597	0598	0598	0599	0599	0600	0600	0601	0601	0602	0602	0603	
	0603	0604	0604	0613	0614	0614	0615	0615	0616	0616	0617	0617	0618	0618	0619	0619	0620	0620	0621	
	0621	0622	0623	0623	0624	0624	0625	0626	0626	0626	0627	0627	0627	0630	0630	0630	0631	0631	0631	
	0632	0632	0632	0633	0633	0633	0634	0634	0634	0635	0635	0635	0636	0636	0636	0637	0637	0637	0639	
	0639	0639	0640	0640	0640	0645	0645	0645	0645	0645	0645									
N	0209	0209	0209	0210	0211	0211	0215	0216	0216	0220	0220	0220								
AB	0005	0009	0484	0604																
AG	0005	0009	0597	0605	0614															
AI	0005	0268	0269	0270	0271	0272	0273	0274	0275	0276	0303	0304	0305	0306	0307	0308	0309	0320	0321	
	0322	0323	0324	0325	0326	0327	0328	0329	0330	0331	0332	0333	0334	0335	0336	0337	0338	0339	0340	
	0341	0342	0343	0348	0349	0359	0359	0359	0359	0359	0359	0362	0367	0367	0367	0367	0367	0367	0371	
	0371	0371	0371	0371	0371	0372	0372	0372	0372	0372	0372	0373	0373	0373	0373	0373	0373	0383	0383	
	0384	0384	0385	0386	0386	0387	0387	0388	0390											
AR	0397	0475																		
DA	0005	0213	0214	0216	0396															
DJ	0579	0583	0583	0584																
DM	0574	0588																		
DN	0390	0396	0437	0437	0442	0556														
DP	0555																			
D1	0005	0009	0598	0606	0615															
D2	0005	0009	0599	0607	0616															
D3	0005	0009	0600	0608	0617															
ED	0392	0544	0593	0642																
EL	0005	0009	0414	0415	0416	0418	0419	0420	0421	0422	0423	0424	0425	0426	0427					
EN	0391	0554	0557																	
FD	0393	0544	0594	0642																
FK	0194	0204																		
GE	0193	0194	0196																	
GM	0133	0160	0173	0180	0183	0191	0193	0207	0390	0391										
GP	0005	0009	0183	0184	0185	0186	0187													
IH	0582	0588																		
II	0581	0582	0583																	
IM	0582	0588																		
JA	0005	0222	0225																	
ND	0584	0588																		
NM	0584	0588																		
NN	0390	0523																		
NY	0584	0585	0588																	
P1	0114	0115	0194																	

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS																		
RE	0138	0165	0178	0181	0184	0185	0186	0187	0192	0198	0207	0383	0397	0485					
RX	0005	0391																	
SS	0005	0009	0406	0407	0408	0554	0555	0556											
TS	0582	0588																	
TO	0006	0009																	
VX	0005	0391	0551	0552	0553														
XX	0005	0009	0481	0482	0601	0602													
ABR	0005	0484	0485	0488	0488	0489	0489	0489	0493	0493	0498	0498	0500	0501	0542	0604	0612	0612	0621
	0621	0640	0651																
ACC	0005	0111	0651																
ARG	0006	0009																	
CJ3	0009	0189																	
CJ4	0009	0190																	
CMU	0009	0195																	
DAD	0005	0121	0122	0123	0124	0125	0126	0127	0128	0129	0130	0131	0132	0209	0211	0212	0212	0213	0214
	0216																		
DJL	0231	0240	0354	0436	0471	0534	0574												
DJG	0009	0227	0231	0564	0579														
DLI	0005	0526	0537	0626	0635														
DLS	0005	0527	0539	0627	0637														
END	0409	0446																	
ERR	0009	0119	0157	0379	0391														
FJ2	0134	0161	0168	0174	0180	0184	0188	0207											
FJ3	0135	0162	0169	0175	0180	0185	0189	0207											
FJ4	0136	0163	0170	0176	0180	0186	0190	0207											
FJ5	0137	0164	0171	0177	0180	0187	0207												
IRC	0147	0150	0217	0218	0396	0524													
KEF	0108	0586	0586	0655	0656														
KPR	0564	0566	0567	0653															
KSW	0007	0105	0106																
NMT	0650	0651																	
NDA	0147	0150	0208																
NDE	0220	0227	0240	0354	0436	0471	0534												
NHE	0220	0228	0240	0354	0381	0436	0471	0534											
NIT	0390	0391	0396	0545	0590	0592	0643												
NME	0220	0227	0240	0354	0436	0471	0534												
NYE	0220	0226	0226	0227	0240	0351	0354	0436	0471	0534									
PAN	0447	0448																	
PER	0391	0557																	
REC	0192	0196																	
REM	0009	0180	0181	0182	0201	0277	0283	0289	0295	0310	0311	0312	0313	0314	0315	0320	0326	0332	0338
	0348	0349	0468	0505	0506	0550	0569												
RXB	0005	0009	0503	0516	0623														
THE	0228	0230																	
TSE	0220	0230	0240	0354	0381	0436	0471	0534											
TUH	0010	0197	0198	0205	0283	0284	0285	0286	0287	0288	0289	0290	0291	0292	0293	0294	0295	0296	0297
	0298	0299	0300	0313	0314	0315	0326	0327	0328	0329	0330	0331	0332	0333	0334	0335	0336	0337	0338
	0339	0340	0341	0342	0343	0349	0506												
TUS	0196	0197	0205																
VXB	0005	0009	0504	0517	0624														
VXE	0005	0551	0552	0553															
XXX	0005	0009	0409																
AAMA	0385	0388																	
ABRR	0485	0488																	

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS																		
AGBR	0005	0597	0605	0614	0630														
AIDH	0005	0009	0277	0278	0279	0280	0281	0282	0283	0284	0285	0286	0287	0288	0289	0290	0291	0292	0293
	0294	0295	0296	0297	0298	0299	0300	0310	0311	0312	0313	0314	0315	0319	0346	0357	0364	0369	0375
	0376	0377	0450	0451	0452														
ARGO	0006	0009																	
ASHR	0006	0483	0492	0492	0497	0497	0527	0603	0611	0611	0620	0620	0627						
AIBR	0005	0482	0491	0491	0496	0496	0526	0527	0538	0602	0610	0610	0619	0619	0626	0627	0636		
AIIC	0005	0009	0357	0399	0475	0475	0476	0476	0476										
CASE	0226	0225	0239	0353	0435	0470	0529	0561											
CJ25	0009	0188																	
CONV	0009	0115	0279	0280	0281	0282	0285	0286	0287	0288	0291	0292	0293	0294	0297	0298	0299	0300	0322
	0323	0324	0325	0328	0329	0330	0331	0334	0335	0336	0337	0340	0341	0342	0343	0384	0386	0387	0388
	0392	0393	0402	0406	0407	0408	0409	0432	0437	0495	0496	0497	0498	0593	0594	0614	0615	0616	0617
	0618	0619	0620	0621															
CON1	0191	0203																	
CON2	0198	0201	0468	0550	0569														
DAJ3	0009																		
DAJ4	0009																		
DDJ0	0578	0579																	
DJUL	0227																		
DLJ3	0009																		
DLJ4	0009																		
DMIN	0141	0634	0573	0588															
DSUP	0006	0209	0113	0541	0576	0639													
DTLA	0564	0571	0572																
DUMF	0005	0009																	
DUM1	0005	0009																	
DUM2	0005	0009																	
D1BR	0005	0598	0606	0615	0631														
D2BR	0005	0599	0607	0616	0632														
D3BR	0005	0600	0608	0617	0633														
ELRV	0391																		
GDIF	0390	0391	0396	0546	0590	0592	0644												
MEFL	0109	0655																	
NARG	0009	0234	0235	0237															
NCST	0147	0150	0158	0159	0167														
NEPH	0558	0559	0559	0560															
NERR	0147	0150	0156																
NKOZ	0009	0147	0150	0440															
NMAX	0120	0157	0379	0390	0391	0396	0590	0592											
NMNE	0220	0229	0240	0354	0381	0436	0471	0534											
NSEC	0009	0147	0150																
ORB1	0223	0225																	
ORB2	0224	0225																	
PARA	0390																		
RADV	0391	0394	0590	0592	0595														
RATE	0005	0403	0404	0405	0406	0407	0408	0410	0410	0410	0446	0446	0446	0446	0447				
REAL	0010	0182																	
RXBM	0005	0503	0505	0513	0547	0623	0645	0651											
TIME	0577	0578	0580	0580	0582														
TMNE	0229	0230																	
TSEP	0230	0231	0564																
VXBM	0005	0504	0506	0514	0547	0624	0645	0651											
WRTC	0651																		

*****F O R T R A N C R O S S R E F E R E N C E L I S T I N G*****

SYMBOL	INTERNAL STATEMENT NUMBERS																		
XLAB	0564	0658																	
XLAB	0564	0571																	
ALLOT	0580																		
ALLBR	0005	0481	0490	0490	0495	0495	0526	0536	0601	0609	0609	0618	0618	0626	0634				
BBRKR	0396																		
BRKR2	0590																		
BRKR4	0592																		
CCCEF	0006	0009																	
DADIN	0006	0127	0128	0129	0130	0131	0132	0211	0522										
DAJ2S	0009																		
DASUM	0009	0540	0638																
DLJ2S	0009																		
DLSUM	0009																		
DSQRT	0194	0196	0198																
HMSRZ	0381																		
IDINT	0578																		
INPUT	0147	0150	0155	0241	0266	0317	0355	0382	0390	0395	0518								
KLAST	0564	0659																	
KPAGE	0107																		
NCASE	0220	0225																	
NKOZD	0009	0147	0150																
NLONG	0009	0147	0150																
NSECD	0009	0147	0150	0151	0153	0562													
NSECL	0151	0562																	
NSEC F	0009	0147	0150	0232															
NUNIT	0147	0150	0242	0247	0252	0256	0265	0356	0361	0366	0370								
NYEIG	0351																		
NYMIN	0585																		
RADVM	0394	0544	0595	0642															
RHMSZ	0582																		
RXBMC	0006	0505	0510																
SCCEF	0006	0009																	
SUPPC	0233																		
TIMCA	0564																		
TIMEC	0381	0577																	
VXBMC	0006	0506	0511																
XREAL	0005	0139	0143																
AINPUT	0005	0220	0243	0245	0248	0250	0253	0255	0257	0258	0259	0261	0262	0263	0268	0269	0270	0271	0272
	0273	0274	0275	0276	0277	0278	0279	0280	0281	0282	0283	0284	0285	0286	0287	0288	0289	0290	0291
	0292	0293	0294	0295	0296	0297	0298	0299	0300	0303	0304	0305	0306	0307	0308	0309	0310	0311	0312
	0313	0314	0315	0319	0320	0321	0322	0323	0324	0325	032	0327	0328	0329	0330	0331	0332	0333	0334
	0335	0336	0337	033H	0339	0340	0341	0342	0343	0346	034H	0349							
ARGMUT	0006	0009																	
ASHORT	0006	0009	0483	0603															
A1108R	0305	0399	0400	0400	0402	0402	0478	0479											
ETIMES	0009	0140	0571	0572	0572	0573	0574	0577	0590	0592	0650	0658							
JULCAL	0584																		
KCOUNT	0009	0565	0587	0628	0652	0652	0653	0654											
LCP023	0117	0118																	
LPCOEF	0004	0005	0413	0414	0415	0416	0418	0418	0419	0420	0421	0422	0423	0424	0425	0426	0427	0429	0429
	0429	0432	0432	0455	0456														
NBRWR1	0009	0147	0150																
NSHORT	0009	0147	0150	0390	0396	0462	0589												
NSUPPC	0009	0147	0150	0152	0154	05e3													

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS
NSUPPE	0152 0563
SLITET	0117
SSWTCH	0106

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
1	0119	0118 0118 0382
2	0156	0155
3	0157	0156
4	0158	0156 0156
5	0159	0158
6	0160	0159
7	0167	0159 0159
8	0168	0167
9	0173	0167
10	0180	0158
11	0183	0158 0166 0167 0172 0179
28	0389	0382
42	0559	0659 0659
100	0111	0110
300	0662	0155 0155
421	0222	0221
422	0567	0566 0566
423	0568	0566
913	0208	
914	0209	0208
915	0213	0208 0208
916	0216	0215
917	0218	0217 0217
918	0220	0217
1000	0008	
1001	0003	
1003	0011	
1004	0096	
1005	0144	
1011	0219	
1800	0012	0142 0148 0199 0202 0433 0570
1801	0013	0542 0640
1802	0014	0536 0634
1803	0015	0537 0635
1804	0016	0538 0636
1805	0017	0547 0645
1806	0018	0539 0637
1808	0019	0520
1810	0020	0455
1811	0021	0456
1816	0022	0474 0487
1817	0023	0477 0499 0521
1818	0024	0515
1819	0025	0473
1820	0026	0486
1821	0027	0508
1822	0028	0205
1823	0029	0204
1825	0030	0512
1827	0031	0203
1830	0032	0453 0454 0457 0458 0459 0460 0530 0531 0532 0533 0543 0641 0646 0647 0648 0649
1831	0033	0238
1832	0034	0248 0364
1833	0035	0250 0362

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES													
1834	0036	0253	0369												
1835	0037	0255	0367												
1836	0038	0243	0357												
1837	0039	0245	0359												
1838	0040	0257	0375	0450											
1839	0041	0261	0371												
1840	0042	0258	0376	0451											
1841	0043	0262	0372												
1842	0044	0259	0377	0452											
1843	0045	0263	0373												
1844	0046	0630													
1845	0047	0631													
1846	0048	0632													
1847	0049	0633													
1848	0050	0540	0638												
1849	0051	0541	0639												
1851	0052	0150													
1852	0053	0149													
1854	0054	0206													
1855	0055	0548													
1857	0056	0200	0461	0549	0568										
1858	0057	0352													
1859	0058	0472													
1860	0059	0475	0476	0478	0479	0488	0489	0500	0501	0510	0511	0513	0514	0516	0517
1861	0060	0507													
1862	0061	0509													
1863	0062	0519													
1864	0063	0523													
1865	0064	0522													
1866	0065	0524													
1867	0066	0545	0643												
1868	0067	0546	0644												
1869	0068	0379													
1870	0069	0445													
1871	0070	0446													
1872	0071	0438													
1873	0072	0449													
1874	0073	0434													
1875	0074	0469													
1876	0075	0528													
1877	0076	0560													
1878	0077	0380													
1879	0078	0544	0642												
1880	0079	0201	0468	0550	0569										
1881	0080	0448													
1882	0081	0239	0353	0435	0470	0529	0561								
1883	0082	0463													
1884	0083	0465													
1885	0084	0467													
1886	0085	0235													
1887	0086	0442													
1888	0087	0439													
1889	0088	0444													
1890	0089	0441													

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES			
2142	0381				
3002	0383	0382	0382		
3999	0090	0225			
5034	0155				
5042	0117				
6002	0091	0139	0143		
6003	0092	0147			
6004	0093	0180			
6005	0094	0207			
6006	0095	0220			
6010	0097	0240	0354	0436	0471
6039	0098	0662			
6040	0099	0157			
6041	0100	0116			
6050	0101	0209			
6085	0102	0535	0629		
6085	0103	0534	0588		
7001	0145				
7002	0146				
7003	0441	0440	0440		
7004	0444	0440			
7005	0445	0443			
7016	0572	0658			
7900	0139	0661			
7998	0659	0658	0658		
7999	0660	0659			
8001	0105				
8002	0106	0104			
8050	0604	0596			
8051	0621	0613			
8052	0624	0622			
8053	0627	0625			
8056	0589	0587	0587		
8057	0588	0587			
8058	0113	0112			
8059	0576	0575			
8060	0656	0655			
8061	0657	0655	0655		
8062	0590	0589	0589		
8063	0592	0589			
8064	0593	0591			
8070	0413	0411	0412		
8071	0418	0417			
8072	0432	0430	0431		
8073	0429	0428			
8074	0463	0462			
8075	0465	0462			
8076	0467	0462			
8077	0468	0464	0466		
8098	0402	0401			
8099	0399	0398			
8100	0266	0265	0265		
8101	0267	0266	0266		
8102	0302	0266	0266		

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES				
8103	0303	0302				
8104	0268	0267				
8107	0283	0316				
8110	0317	0265				
8111	0318	0317	0317			
8112	0345	0317	0317			
8113	0346	0345				
8114	0319	0318				
8116	0349	0347				
8120	0351	0301	0344			
8121	0326	0350				
8150	0484	0480				
8151	0498	0494				
8152	0506	0502				
8153	0527	0525				
8190	0396	0395	0395			
8191	0397	0395				
8210	0242	0241				
8211	0243	0242				
8212	0245	0242	0242			
8220	0247	0241	0241			
8221	0248	0247				
8222	0250	0247	0247			
8230	0252	0241				
8231	0253	0252				
8232	0255	0252	0252			
8250	0256	0244	0246	0249	0251	0254
8251	0257	0256				
8252	0261	0256	0256			
8260	0264	0260				
8271	0519	0518	0518	0518		
8272	0525	0518				
8303	0536					
8403	0629	0628				
8404	0650	0628	0628			
8405	0654	0653	0653			
8406	0655	0653				
9141	0211	0210				
9181	0233	0232	0232			
9182	0238	0232	0237	0237		
9183	0235	0234	0234	0237		
9184	0237	0234				
9210	0356	0355				
9211	0357	0356	0356			
9212	0359	0356				
9220	0361	0355	0355			
9221	0362	0361				
9222	0364	0361	0361			
9230	0366	0355				
9231	0367	0366				
9232	0369	0366	0366			
9250	0370	0358	0360	0363	0365	0368
9251	0371	0370				
9252	0375	0370	0370			

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
9260	0378	0374

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          COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
               CSUBROUTINE ADLH                                                                          00057470
               CSUBROUTINE ADLH                                                                          00057480
ISN 0002             SUBROUTINE ADLH (DLJ2S,DLJ3,DLJ4,DLSUM,TH,E,G,A,R,ET,F,CAPG,CAPL,                 00057490
                    1CMU,CJ2S,CJ3,CJ4,D)                                                                 00057500
ISN 0003             IMPLICIT REAL*8(A-H,O-Z,$)                                                        00057510
ISN 0004             DOUBLE PRECISION DLJ2S,DLJ3,DLJ4,DLSUM,TH,E,G,A,R,ET,F,CAPG,CAPL,                 00057520
                    1CMU,CJ2S,CJ3,CJ4,D                                                                  00057530
ISN 0005             DIMENSION D(19)                                                                   00057540
ISN 0006             D(1)=TH*TH                                                                        00057550
ISN 0007             D(2)=D(1)*D(1)                                                                    00057560
ISN 0008             D(3)=E*F                                                                          00057570
ISN 0009             D(4)=E*D(3)                                                                       00057580
ISN 0010             D(5)=ET*ET*ET                                                                     00057590
ISN 0011             D(6)=(3.0D0*CMU**4*CJ2S/(128.0D0*CAPG**7))*(8.0D0*D(1)*(1.0D0-5.0                 00057600
                    1D0*D(1))+D(3)*(5.0D0-18.0D0*D(1)+5.0D0*D(2))-2.0D0*D(3)*(1.0D0-D                  00057610
                    2(1))*(1.0D0-15.0D0*D(1))*DCOS(2.0D0*G))                                             00057620
ISN 0012             D(7)=(3.0D0*CMU**4*CJ2S/(512.0D0*CAPL*CAPG**6))*(A/R)**3                          00057630
ISN 0013             D(8)=8.0D0*(9.0D0-26.0D0*D(1)+49.0D0*D(2))+4.0D0*D(3)*(37.0D0-                    00057640
                    198.0D0*D(1)+37.0D0*D(2))+16.0D0*D(5)*(1.0D0-3.0D0*D(1))**2                          00057650
ISN 0014             D(9)=2.0D0*E*(16.0D0*(1.0D0-3.0D0*D(1))**2*(1.0D0-D(5))/D(3)+                     00057660
                    14.0D0*(19.0D0-30.0D0*D(1)+35.0D0*D(2))+D(3)*(73.0D0-234.0D0*D(1)+                   00057670
                    2121.0D0*D(2)))*DCOS(F)                                                              00057680
ISN 0015             D(10)=4.0D0*D(3)*(4.0D0*(1.0D0-3.0D0*D(1))**2*(1.0D0-D(5))/D(3)+29                  00057690
                    1.0D0-66.0D0*D(1)+45.0D0*D(2))*DCOS(2.0D0*F)+2.0D0*D(4)*(11.0D0-30.                  00057700
                    20D0*D(1)+27.0D0*D(2))*DCOS(3.0D0*F)                                                 00057710
ISN 0016             D(11)=-3.0D0*D(4)*(1.0D0-3.0D0*D(1))*DCOS(F-2.0D0*G)-2.0D0*D(3)*                    00057720
                    1(1.0D0-3.0D0*D(1))*((1.0D0-D(5))/D(3)+8.0D0)*DCOS(2.0D0*G)+E*                       00057730
                    2(4.0D0*(1.0D0-3.0D0*D(1))*(1.0D0-D(5))/D(3)-32.0D0-D(3)*(17.0D0-                    00057740
                    3147.0D0*D(1)))*DCOS(F+2.0D0*G)                                                      00057750
ISN 0017             D(12)=-4.0D0*(13.0D0-27.0D0*D(1)+2.0D0*D(3)*(7.0D0-9.0D0*D(1))+                     00057760
                    13.0D0*D(5)*(1.0D0-3.0D0*D(1)))*DCOS(2.0D0*(F+G))-E*(28.0D0*(1.0D0-                  00057770
                    23.0D0*D(1))*(1.0D0-D(5))/D(3)+32.0D0*(1.0D0-4.0D0*D(1))-D(3)*(15.                   00057780
                    30D0-77.0D0*D(1)))*DCOS(3.0D0*F+2.0D0*G)                                             00057790
ISN 0018             D(13)=-2.0D0*D(3)*(1.0D0-3.0D0*D(1))*(5.0D0*(1.0D0-D(5))/D(3)+4.                    00057800
                    10D0)*DCOS(4.0D0*F+2.0D0*G)-3.0D0*D(4)*(1.0D0-3.0D0*D(1))*DCOS(5.0                   00057810
                    2D0*F+2.0D0*G)                                                                       00057820
ISN 0019             D(14)=9.0D0*D(4)*DCOS(F+4.0D0*G)+54.0D0*D(3)*DCOS(2.0D0*F+4.0D0*                    00057830
                    1G)+E*(148.0D0-13.0D0*D(3))*DCOS(3.0D0*F+4.0D0*G)+20.0D0*(2.0D0                      00057840
                    2+7.0D0*D(3))*DCOS(4.0D0*(F+G))                                                      00057850
ISN 0020             D(14)=(D(14)+3.0D0*E*(28.0D0+17.0D0*D(3))*DCOS(5.0D0*F+4.0D0*G)+                    00057860
                    154.0D0*D(3)*DCOS(6.0D0*F+4.0D0*G)+9.0D0*D(4)*DCOS(7.0D0*F+4.0D0*                    00057870
                    2G))*(1.0D0-D(1))**2                                                                 00057880
ISN 0021             DLJ2S=D(6)+D(7)*(D(8)+D(9)+D(10)+4.0D0*(1.0D0-D(1))*(D(11)+D(12)+                   00057890
                    1D(13))+D(14))                                                                       00057900
ISN 0022             D(15)=(-3.0D0/8.0D0)*DSQRT(1.0D0-D(1))*(1.0D0-5.0D0*D(1))                           00057910
ISN 0023             D(16)=5.0D0/8.0D0*DSQRT((1.0D0-D(1))**3)                                            00057920
ISN 0024             D(17)=(-3.0D0/64.0D0)*(3.0D0-30.0D0*D(1)+35.0D0*D(2))                               00057930
ISN 0025             D(18)=5.0D0/16.0D0*(1.0D0-D(1))*(1.0D0-7.0D0*D(1))                                  00057940
ISN 0026             D(19)=(-35.0D0/64.0D0)*(1.0D0-D(1))**2                                              00057950
ISN 0027             DLJ3=CMU**3*CJ3/CAPL**5*(D(15)*((A/R)**4*DSIN(F+G)-E/ET**5*DSIN                     00057960
                    1(G))+D(16)*(A/R)**4*DSIN(3.0D0*(F+G)))                                              00057970
ISN 0028             DLJ4=CMU**4*CJ4/CAPL**7*(D(17)*((A/R)**5-1.0D0/ET**7*(1.0D0+3.0D0                   00057980
                    1*D(3)/2.0D0))+D(18)*((A/R)**5*DCOS(2.0D0*(F+G))-3.0D0*D(3)/(4.0D0                   00057990
                    2*ET**7)*DCOS(2.0D0*G))+D(19)*(A/R)**5*DCOS(4.0D0*(F+G)))                            00058000
ISN 0029             DLSUM=DLJ2S+DLJ3+DLJ4                                                               00058010
ISN 0030             RETURN                                                                              00058020
ISN 0031             END                                                                                 00058030
```
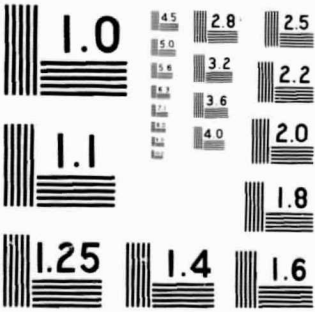

****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS																		
A	0002	0004	0012	0027	0027	0028	0028	0028											
B	0002	0004	0005	0006	0007	0007	0007	0008	0009	0009	0010	0011	0011	0011	0011	0011	0011	0011	0011
	0011	0012	0013	0013	0013	0013	0013	0013	0013	0013	0014	0014	0014	0014	0014	0014	0014	0014	0014
	0015	0015	0015	0015	0015	0015	0015	0015	0015	0015	0016	0016	0016	0016	0016	0016	0016	0016	0016
	0016	0016	0016	0017	0017	0017	0017	0017	0017	0017	0017	0017	0017	0017	0017	0018	0018	0018	0018
	0018	0018	0018	0019	0019	0019	0019	0019	0020	0020	0020	0020	0020	0020	0021	0021	0021	0021	0021
	0021	0021	0021	0021	0021	0022	0022	0022	0023	0023	0024	0024	0024	0025	0025	0025	0026	0026	0027
	0027	0028	0028	0028	0028	0028													
E	0002	0004	0008	0008	0009	0014	0016	0017	0019	0020	0027								
F	0002	0004	0014	0015	0015	0016	0016	0017	0017	0018	0018	0019	0019	0019	0019	0020	0020	0020	0027
	0027	0028	0028																
G	0002	0004	0011	0016	0016	0016	0017	0017	0018	0018	0019	0019	0019	0019	0020	0020	0020	0027	0027
	0027	0028	0028	0028															
R	0002	0004	0012	0027	0027	0028	0028	0028											
ET	0002	0004	0010	0010	0010	0027	0028	0028											
TH	0002	0004	0006	0006															
CJ3	0002	0004	0027																
CJ4	0002	0004	0028																
CMU	0002	0004	0011	0012	0027	0028													
ADLH	0002																		
CAPG	0002	0004	0011	0012															
CAPL	0002	0004	0012	0027	0028														
CJ2S	0002	0004	0011	0012															
DCOS	0011	0014	0015	0015	0016	0016	0016	0017	0017	0018	0018	0019	0019	0019	0019	0020	0020	0020	0028
	0028	0028																	
DLJ3	0002	0004	0027	0029															
DLJ4	0002	0004	0028	0029															
DSIN	0027	0027	0027																
DLJ2S	0002	0004	0021	0029															
DLSUM	0002	0004	0029																
DSQRT	0022	0023																	



```
          COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
              SUBROUTINE ALLOT                                                                    00058040
   ISN 0002           REAL FUNCTION ALLOT *8(X)                                                   00058050
   ISN 0003           IMPLICIT REAL*8(A-H,O-Z,$)                                                  00058060
                  C                                                                               00058070
                  C     VERSION OF 07/22/63                                                       00058080
                  C           FORTRAN FUNCTION                                                    00058090
                  C                                                                               00058100
                  C     PURPOSE                                                                   00058110
                  C           REDUCES AN ANGLE OF ANY MAGNITUDE AND SIGN BY MODULUS 2 PI        00058120
                  C           AND ADDS 2 PI IF ANGLE IS NEGATIVE.  THE RESULTING ANGLE IS       00058130
                  C           POSITIVE BETWEEN 0 AND +2 PI RADIANS.                               00058140
                  C                                                                               00058150
                  C                                                                               00058160
                  C     CALLING SEQUENCE                                                          00058170
                  C      D    NAME = ALLOT (X)                                                    00058180
                  C     NAME CHANGED 11/15/68 FROM ALLOTZ TO ALLOT                                00058190
                  C                                                                               00058200
                  C     INPUT                                                                     00058210
                  C           X    = ANGLE IN RADIANS                                             00058220
                  C                                                                               00058230
                  C           X MUST BE AVAILABLE IN CALLING PROGRAM IN DOUBLE PRECISION         00058240
                  C           FORM.                                                               00058250
                  C                                                                               00058260
                  C     OUTPUT                                                                    00058270
                  C           NAME = ANGLE IN RADIANS BETWEEN 0 AND + 2 PI RADIANS              00058280
                  C                                                                               00058290
                  C           NAME IS RETURNED TO CALLING PROGRAM IN DOUBLE PRECISION           00058300
                  C           FORM.                                                               00058310
                  C                                                                               00058320
                  C     REFERENCE                                                                 00058330
                  C           ******                                                              00058340
                  C                                                                               00058350
                  C     METHOD                                                                    00058360
                  C           ******                                                              00058370
                  C                                                                               00058380
                  C     RESTRICTIONS                                                              00058390
                  C           ******                                                              00058400
   ISN 0004         1 CONTINUE                                                                   00058410
                  C                                                                               00058420
                  C     ACCURACY                                                                  00058430
                  C           INTERNAL ARITHMETIC IS PERFORMED IN DOUBLE PRECISION.             00058440
                  C                                                                               00058450
                  C     REQUIRED SUBPROGRAMS                                                      00058460
                  C           DMAD                                                                00058470
                  C                                                                               00058480
                  C                                                                               00058490
                  C     TIMING                                                                    00058500
                  C           NO ESTIMATE AVAILABLE                                               00058510
                  C                                                                               00058520
                  C                                                                               00058530
                  C                                                                               00058540
                  C                                                                               00058550
                  C***** START PROGRAM ************************************************************00058560
                  C                                                                               00058570
```

```
ISN 0005          2 ALLOT =DMAD(X,6.28318530717958600)                    00058580
ISN 0006          3 IF (ALLOT ) 4,5,5                                     00058590
ISN 0007          4 ALLOT =ALLOT +6.28318530717958600                     00058600
ISN 0008          5 RETURN                                                00058610
ISN 0009            END                                                   00058620
```

*****F O R T R A N C R O S S R E F E R E N C E L I S T I N G*****

SYMBOL	INTERNAL STATEMENT NUMBERS
X	0002 0005
DMAD	0005
ALLOT	0002 0005 0006 0007 0007

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
1	0004	
2	0005	
3	0006	
4	0007	0006
5	0008	0006 0006

```
        COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
            SUBROUTINE ATANQ                                                                    00060270
ISN 0002            REAL FUNCTION ATANQ*8(S,C)                                                  00060280
ISN 0003            IMPLICIT REAL*8(A-H,O-Z,$)                                                  00060290
                    C                                                                           00060300
                    C     VERSION OF 03/03/64                                                   00060310
                    C           FORTRAN FUNCTION                                                00060320
                    C                                                                           00060330
                    C     PURPOSE                                                               00060340
                    C           COMPUTES THE ARCTANGENT OF AN ANGLE WITH PROPER ALLOCATION      00060350
                    C           OF QUADRANT TO THE ANGLE BETWEEN 0 AND + 2 PI RADIANS.          00060360
                    C                                                                           00060370
                    C     CALLING SEQUENCE                                                      00060380
                    C           NAME = ATANQ (S,C)                                              00060390
                    C                                                                           00060400
                    C     INPUT                                                                 00060410
                    C           S     = D*SIN(A)                                                00060420
                    C           C     = D*COS(A)                                                00060430
                    C             WHERE D IS AN ARBITRARY POSITIVE CONSTANT (NORMALLY           00060440
                    C             D = +1.0)                                                     00060450
                    C                                                                           00060460
                    C     OUTPUT                                                                00060470
                    C           NAME = ANGLE A IN RADIANS BETWEEN 0 AND + 2 PI RADIANS          00060480
                    C                                                                           00060490
                    C     REFERENCE                                                             00060500
                    C           REFER TO MATHEMATICAL DESCRIPTION IN SUBPROGRAM WRITEUP         00060510
                    C     METHOD                                                                00060520
                    C           USES FORTRAN FUNCTION DATAN. TESTS THE SIGNS OF                 00060530
                    C           SINE AND COSINE, THEN ADDS OR SUBSTRACTS APPROPRIATE            00060540
                    C           FRACTIONS OF 2 PI RADIANS TO ASSIGN ANGLE TO PROPER             00060550
                    C           QUADRANT BETWEEN 0 AND + 2 PI RADIANS                           00060560
                    C                                                                           00060570
                    C     RESTRICTIONS                                                          00060580
                    C           ATANQ(0/0) = 0 BY DEFINITION                                    00060590
                    C     ACCURACY                                                              00060600
                    C           ******                                                          00060610
                    C                                                                           00060620
                    C     REQUIRED SUBPROGRAMS                                                  00060630
                    C           NONE                                                            00060640
                    C                                                                           00060650
                    C     TIMING                                                                00060660
                    C           NO ESTIMATE AVAILABLE                                           00060670
                    C                                                                           00060680
                    C                                                                           00060690
                    C                                                                           00060700
                    C                                                                           00060710
ISN 0004            IF (C) 108,100,116                                                          00060720
ISN 0005          100 IF(S)102,104,106                                                          00060730
ISN 0006          102 ATANQ=4.712388980C                                                        00060740
ISN 0007            RETURN                                                                      00060750
ISN 0008          104 ATANQ=0.0D0                                                               00060760
ISN 0009            RETURN                                                                      00060770
ISN 0010          106 ATANQ=1.570796330D0                                                       00060780
ISN 0011            RETURN                                                                      00060790
ISN 0012          108 IF(S)110,112,114                                                          00060800
```

```
ISN 0013        110 ADD=3.1415926535D0                                          00060810
ISN 0014            GO TO 124                                                   00060820
ISN 0015        112 ATANQ=3.14159265D0                                          00060830
ISN 0016            RETURN                                                      00060840
ISN 0017        114 ADD=3.14159265D0                                            00060850
ISN 0018            GO TO 132                                                   00060860
ISN 0019        116 IF (S) 118,120,122                                          00060870
ISN 0020        118 ADD=6.283 185 307D0                                         00060880
ISN 0021            GO TO 132                                                   00060890
ISN 0022        120 ATANQ=0.0D0                                                 00060900
ISN 0023            RETURN                                                      00060910
ISN 0024        122 ADD=0.0D0                                                   00060920
ISN 0025        124 IF (DABS(S)-DABS(C)) 126,128,130                            00060930
ISN 0026        126 ATANQ=DATAN(S/C)+ADD                                        00060940
ISN 0027            RETURN                                                      00060950
ISN 0028        128 ATANQ=0.785 398 163D0+ADD                                   00060960
ISN 0029            RETURN                                                      00060970
ISN 0030        130 ATANQ=1.570 796 326D0-DATAN(C/S)+ADD                        00060980
ISN 0031            RETURN                                                      00060990
ISN 0032        132 IF (DABS(S)-DABS(C)) 126,134,136                            00061000
ISN 0033        134 ATANQ=-0.785 398 163D0+ADD                                  00061010
ISN 0034            RETURN                                                      00061020
ISN 0035        136 ATANQ=-1.57079633D0-DATAN(C/S)+ADD                          00061030
ISN 0036            RETURN                                                      00061040
ISN 0037            END                                                         00061050
```

*****F O R T R A N C R O S S R E F E R E N C E L I S T I N G*****

SYMBOL	INTERNAL STATEMENT NUMBERS										
C	0002	0004	0025	0026	0030	0032	0035				
S	0002	0005	0012	0019	0025	0026	0030	0032	0035		
ADD	0013	0017	0020	0024	0026	0028	0030	0033	0035		
DABS	0025	0025	0032	0032							
ATANQ	0002	0006	0008	0010	0015	0022	0026	0028	0030	0033	0035
DATAN	0026	0030	0035								

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
100	0005	0004
102	0006	0005
104	0008	0005
106	0010	0005
108	0012	0004
110	0013	0012
112	0015	0012
114	0017	0012
116	0019	0004
118	0020	0019
120	0022	0019
122	0024	0019
124	0025	0014
126	0026	0025 0032
128	0028	0025
130	0030	0025
132	0032	0018 0021
134	0033	0032
136	0035	0032

```
          COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
               CSUBROUTINE ATANZ                                                                  00061060
   ISN 0002            REAL FUNCTION ATANZ*8(S,C)                                                 00061070
   ISN 0003            IMPLICIT REAL*8(A-H,O-Z,$)                                                 00061080
                    C                                                                             00061090
                    C                                                                             00061100
                    C     CALLING SEQUENCE                                                        00061110
                    C      D      NAME = ATANZ(S,C)                                               00061120
                    C                                                                             00061130
                    C     INPUT                                                                   00061140
                    C            S     = SINE OF ANGLE (+ OR -)                                   00061150
                    C            C     = COSINE OF ANGLE (+ OR -)                                 00061160
                    C                                                                             00061170
                    C            INPUT ARGUMENTS MUST BE AVAILABLE IN CALLING PROGRAM IN         00061180
                    C            DOUBLE PRECISION FORM.                                           00061190
                    C                                                                             00061200
                    C     OUTPUT                                                                  00061210
                    C            NAME = ANGLE IN RADIANS BETWEEN 0 AND + 2 PI RADIANS             00061220
                    C                                                                             00061230
                    C            NAME IS RETURNED TO CALLING PROGRAM IN DOUBLE PRECISION          00061240
                    C            FORM.                                                            00061250
                    C                                                                             00061260
                    C     REFERENCE                                                               00061270
                    C            ******                                                           00061280
                    C                                                                             00061290
                    C     METHOD                                                                  00061300
                    C            USES FORTRAN MONITOR FUNCTION DATAN2.  IF ARGUMENT               00061310
                    C            RETURNED BY DATAN2 IS -, 2 PI RADIANS ARE ADDED .                00061320
                    C                                                                             00061330
                    C     RESTRICTIONS                                                            00061340
                    C            ******                                                           00061350
                    C                                                                             00061360
                    C     ACCURACY                                                                00061370
                    C            INTERNAL ARITHMETIC IS PERFORMED IN DOUBLE PRECISION.            00061380
                    C                                                                             00061390
                    C     REQUIRED SUBPROGRAMS                                                    00061400
                    C            NONE                                                             00061410
                    C                                                                             00061420
   ISN 0004            2 CONTINUE                                                                 00061430
                    C                                                                             00061440
                    C     TIMING                                                                  00061450
                    C            NO ESTIMATE AVAILABLE                                            00061460
                    C                                                                             00061470
                    C                                                                             00061480
                    C                                                                             00061490
                    C                                                                             00061500
                    C***** START PROGRAM ***************************************************** 00061510
                    C                                                                             00061520
   ISN 0005            ATANZ = DATAN2(S,C)                                                        00061530
   ISN 0006          3 IF (ATANZ) 4,5,5                                                           00061540
   ISN 0007          4 ATANZ=ATANZ+6.2831853071795860                                             00061550
   ISN 0008          5 RETURN                                                                     00061560
   ISN 0009            END                                                                        00061570
```

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS
C	0002 0005
S	0002 0005
ATAN2	0002 0005 0006 0007 0007
DATAN2	0005

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
2	0004	
3	0006	
4	0007	0006
5	0008	0006 0006

```
        COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
        CSUBROUTINE BBRWR                                                                    00061680
ISN 0002        SUBROUTINE BBRWR(DA,AT,J,K,GDIF,NMAX,NIT,NSHORT,DN)                          00061690
ISN 0003        IMPLICIT REAL*8(A-H,O-Z,$)                                                   00061700
              C VERSION OF 10/02/63                                                          00061710
              C       FORTRAN SUBROUTINE                                                     00061720
              C                                                                              00061730
              C                                                                              00061740
              C PURPOSE                                                                      00061750
              C       COMPUTES BROUWER MEAN ORBITAL ELEMENTS FROM OSCULATING                 00061760
              C       ORBITAL ELEMENTS BY MEANS OF AN ITERATIVE PROCESS.                     00061770
              C                                                                              00061780
              C CALLING SEQUENCE                                                             00061790
              C       CALL BBRWR(DA,AT,J,K,GDIF,NMAX,NIT,NSHORT,DN)                          00061800
              C                                                                              00061810
              C INPUT                                                                        00061820
              C       DA(1)= TRUNCATION FACTOR FOR SEMI-MAJOR AXIS - KILOMETERS              00061830
              C       DA(2)= TRUNCATION FACTOR FOR ECCENTRICITY - DIMENSIONLESS              00061840
              C       DA(3)= TRUNCATION FACTOR FOR INCLINATION - RADIANS                     00061850
              C       DA(4)= TRUNCATION FACTOR FOR RIGHT ASCENSION OF ASCENDING              00061860
              C              NODE - RADIANS                                                  00061870
              C       DA(5)= TRUNCATION FACTOR FOR ARGUMENT OF PERIGEE - RADIANS             00061880
              C       DA(6)= TRUNCATION FACTOR FOR MEAN ANOMALY - RADIANS                    00061890
              C                                                                              00061900
              C       OSCULATING ORBITAL ELEMENTS AT EPOCH TIME                              00061910
              C      AT(1) = SEMI-MAJOR AXIS                    - KILOMETERS                00061920
              C      AT(2) = ECCENTRICITY                       - DIMENSIONLESS             00061930
              C      AT(3) = INCLINATION                        - RADIANS                   00061940
              C      AT(4) = RIGHT ASCENSION OF ASCENDING NODE  - RADIANS                   00061950
              C      AT(5) = ARGUMENT OF PERIGEE                - RADIANS                   00061960
              C      AT(6) = MEAN ANOMALY                       - RADIANS                   00061970
              C                                                                              00061980
              C       J     = MAXIMUM NUMBER OF ITERATIONS ALLOWED                           00061990
              C       NMAX  = MAXIMUM NUMBER OF ITERATIONS ALLOWED                           00062000
              C               IN SOLVING KEPLER'S EQUATION                                   00062010
              C      NSHORT   SHORT-PERIOD PERTURBATIONS INCLUDED (   00 = NO                00062020
              C                                                  LT.0                        00062030
              C                          THE SHORT PERIOD PERTURBATIONS ARE                  00062040
              C                          COMPUTED WITH E" AND I" .                           00062050
              C                                                GT.0                          00062060
              C                          THE SHORT PERIOD PERTURBATIONS ARE                  00062070
              C                          COMPUTED WITH E' AND I' .          )                00062080
              C                                                                              00062090
              C OUTPUT                                                                       00062100
              C       K     = SERIAL NUMBER OF CURRENT ITERATION                             00062110
              C       GDIF  = LAST CORRECTION (E2-E1)/E2                                     00062120
              C               IN SOLVING KEPLER'S EQUATION.                                  00062130
              C       NIT   = SERIAL NUMBER OF CURRENT ITERATION IN SOLVING                  00062140
              C               KEPLER'S EQUATION                                              00062150
              C        DN   = REDUCTION OF MEAN MOTION OF MEAN ANOMALY FROM                  00062160
              C               BROUWER TO KOZAI IN RADIANS PER SECOND.                        00062170
              C                                                                              00062180
              C                                                                              00062190
              C     OUTPUT VIA COMMON                                                        00062200
              C                                                                              00062210
```

```
C          BROUWER MEAN ELEMENTS                                                00062220
C          A110(1) = SEMI-MAJOR AXIS                    - KILOMETERS            00062230
C          A110(2) = ECCENTRICITY                                               00062240
C          A110(3) = INCLINATION                        - RADIANS               00062250
C          A110(4) = RIGHT ASCENSION OF ASCENDING NODE  - RADIANS               00062260
C          A110(5) = ARGUMENT OF PERIGEE                - RADIANS               00062270
C          A110(6) = MEAN ANOMALY                       - RADIANS               00062280
C     REQUIRED SUBPROGRAMS                                                      00062290
C          07/22/63  ALLOT                                                      00062300
ISN 0004      2 CONTINUE                                                        00062310
C          07/17/63  BRWR1                                                      00062320
C          01/31/64  BRWR2                                                      00062330
C                    BRWR4                                                     00062340
C                                                                              00062350
C                                                                              00062360
C     TIMING                                                                   00062370
C          NO ESTIMATE AVAILABLE                                               00062380
C                                                                              00062390
C                                                                              00062400
C                                                                              00062410
C     PROGRAM MODIFICATIONS                                                    00062420
C                                                                              00062430
C***** START PROGRAM ***************************************************      00062440
C                                                                              00062450
ISN 0005    100 FORMAT (///26H ******* WARNING *******  /79H NO CONVERGENCE IN BBRW00062460
           1R SUBROUTINE.  BROUWER MEAN ELEMENTS ARE NOT ACCURATE   /////)     00062470
C                                                                              00062480
ISN 0006        DIMENSION DUM1(100)                                            00062490
ISN 0007        DIMENSION DA(6),AT(6),A110(6),DUMX(18),AC(6),DAT(6),TDAT(6)    00062500
C                                                                              00062510
ISN 0008        COMMON DUM1,A110,DUMX,AC                                       00062520
C                                                                              00062530
ISN 0009        K = 0                                                          00062540
ISN 0010        DO 10 N=1,6                                                    00062550
ISN 0011     10 A110(N) = AT(N)                                                00062560
C                                                                              00062570
ISN 0012      1 CALL BRWR1(DN)                                                 00062580
ISN 0013        IF(NSHORT)101,101,102                                          00062590
ISN 0014    101 CALL BRWR2(0.0D0,      E,F,RADV,GDIF,NMAX,NIT)                 00062600
ISN 0015        GO TO 103                                                      00062610
ISN 0016    102 CALL BRWR4(0.0D0,      E,F,RADV,GDIF,NMAX,NIT)                 00062620
C                                                                              00062630
ISN 0017    103 K = K + 1                                                      00062640
ISN 0018        IF (K-J) 4,4,3                                                 00062650
ISN 0019      3 PRINT 100                                                      00062660
ISN 0020        RETURN                                                         00062670
C                                                                              00062680
ISN 0021      4 DO 5 N=1,6                                                     00062690
ISN 0022        DAT(N) = AT(N) - AC(N)                                         00062700
ISN 0023      5 TDAT(N) = DABS(DAT(N))                                         00062710
C                                                                              00062720
ISN 0024        DO 6 N=1,6                                                     00062730
ISN 0025        IF (TDAT(N)-DA(N)) 6,6,8                                       00062740
ISN 0026      6 CONTINUE                                                       00062750
ISN 0027      7 RETURN                                                         00062760
C                                                                              00062770
```

```
ISN 0028          8 DO 9 N=1,6                                                  00062780
ISN 0029          9 A110(N) = A110(N) + DAT(N)                                  00062790
ISN 0030            A110(3)=ALLOT(A110(3))                                      00062800
ISN 0031            A110(4)=ALLOT(A110(4))                                      00062810
ISN 0032            A110(5)=ALLOT(A110(5))                                      00062820
ISN 0033            A110(6)=ALLOT(A110(6))                                      00062830
ISN 0034            GO TO 1                                                     00062840
ISN 0035            END                                                         00062850
```

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS															
E	0014	0016														
F	0014	0016														
J	0002	0018														
K	0002	0009	0017	0017	0018											
N	0010	0011	0011	0021	0022	0022	0022	0023	0023	0024	0025	0025	0028	0029	0029	0029
AC	0007	0008	0022													
AT	0002	0007	0011	0022												
DA	0002	0007	0025													
DN	0002	0012														
DAT	0007	0022	0023	0029												
NIT	0002	0014	0016													
A110	0007	0008	0011	0029	0029	0030	0030	0031	0031	0032	0032	0033	0033			
DABS	0023															
DUMX	0007	0008														
DUM1	0006	0008														
GDIF	0002	0014	0016													
AMAX	0002	0014	0016													
RADV	0014	0016														
TDAT	0007	0023	0025													
ALLOT	0030	0031	0032	0033												
BBRWR	0002															
BRWR1	0012															
BRWR2	0014															
BRWR4	0016															
NSHORT	0002	0013														

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
1	0012	0034
2	0004	
3	0019	0018
4	0021	0018 0018
5	0023	0021
6	0026	0024 0025 0025
7	0027	
8	0028	0025
9	0029	0028
10	0011	0010
100	0005	0019
101	0014	0013 0013
102	0016	0013
103	0017	0015

```
         COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
               CSUBROUTINE BRWR1                                                                  00062860
   ISN 0002          SUBROUTINE BRWR1(DN)                                                         00062870
   ISN 0003          IMPLICIT REAL*8(A-H,O-Z,$)                                                   00062880
                C                                                                               00062890
                C     VERSION OF 07/17/63                                                       00062900
                C           FORTRAN SUBROUTINE                                                  00062910
                C                                                                               00062920
                C     PURPOSE                                                                   00062930
                C     BRWR1 AND BRWR2 CONVERT BROUWER MEAN ORBITAL ELEMENTS TO                  00062940
                C     OSCULATING ORBITAL ELEMENTS AND TO POSITION AND VELOCITY                  00062950
                C     COMPONENTS.  SECULAR AND LONG PERIOD COEFFICIENTS AND OTHER               00062960
                C     INTERMEDIATE QUANTITIES WHICH ARE FUNCTIONS OF THE MEAN                   00062970
                C     ELEMENTS AND THE EARTHS GRAVITATIONAL HARMONICS ONLY (I.E., DO NOT        00062980
                C     VARY WITH TIME AND ARE CONSTANT FOR ANY GIVEN SET OF MEAN                 00062990
                C     ELEMENTS) ARE COMPUTED IN BRWR1 AND PLACED IN COMMON.  BRWR2 CAN          00063000
                C     THEN BE USED TO CALCULATE OSCULATING ORBITAL ELEMENTS FOR ANY             00063010
                C     SPECIFIED VALUE OF DT (TIME ELAPSED FROM EPOCH OF MEAN                    00063020
                C     ELEMENTS).  COMMON IS USED TO TRANSFER INPUT TO SUBROUTINE BRWR1          00063030
                C     FROM CALLING PROGRAM, CONSTANTS AND INTERMEDIATE CALCULATIONS FROM        00063040
                C     BRWR1 TO BRWR2, AND TO RETURN OUTPUT FROM BRWR2 TO CALLING PROGRAM        00063050
                C                                                                               00063060
                C     DUM1 IS A DUMMY VARIABLE INSERTED AS FIRST VARIABLE IN COMMON IN          00063070
                C     BRWR1,BRWR2,AND BRWR4 TO PERMIT SHIFTING OF VARIABLES IN COMMON           00063080
                C     AREA IF DESIRED. THE DIMENSION OF DUM1 MAY BE CHANGED BUT SHOULD          00063090
                C     BE THE SAME IN SUBROUTINES BRWR1,BRWR2,AND BRWR4,AND THE CALLING          00063100
                C     PROGRAM.                                                                  00063110
                C                                                                               00063120
                C     CALLING SEQUENCE                                                          00063130
                C           CALL BRWR1(DN)                                                      00063140
                C                                                                               00063150
   ISN 0004      2001 CONTINUE                                                                  00063160
                C     INPUT VIA COMMON                                                          00063170
                C          BROUWER MEAN ELEMENTS                                                00063180
                C          A110(1) = SEMI-MAJOR AXIS                    - KILOMETERS            00063190
                C          A110(2) = ECCENTRICITY                                               00063200
                C          A110(3) = INCLINATION                        - RADIANS               00063210
                C          A110(4) = RIGHT ASCENSION OF ASCENDING NODE  - RADIANS               00063220
                C          A110(5) = ARGUMENT OF PERIGEE                - RADIANS               00063230
                C          A110(6) = MEAN ANOMALY                       - RADIANS               00063240
                C                                                                               00063250
                C          EARTHS GRAVITATIONAL CONSTANTS                                       00063260
                C                                                                               00063270
                C          GP(1)   = GM(PRODUCT OF G,THE GAUSSIAN CONSTANT SQUARED, AND         00063280
                C                    M, THE MASS OF THE EARTH) - KM. CUBED/SEC. SQUARED         00063290
                C          GP(2)   = K2 )   ZONAL HARMONIC              - KM. SQUARED          00063300
                C          GP(3)   = K3 )   COEFFICIENTS OF THE         - KM. CUBED            00063310
                C          GP(4)   = K4 )   EARTHS GRAVITATIONAL        - KM. 4TH POWER        00063320
                C          GP(5)   = K5 )   FIELD                       - KM. 5TH POWER        00063330
                C                                                                               00063340
                C          ERR     = TRUNCATION FACTOR REQUIRED IN                              00063350
                C                    FUNCTION XKEP                      - RADIANS              00063360
   ISN 0005       1 CONTINUE                                                                    00063370
                C                                                                               00063380
                C     OUTPUT                                                                    00063390
```

```
C           DN = REDUCTION OF MEAN MOTION OF MEAN ANOMALY FROM BROUWER TO  00063400
C                KOZAI IN RADIANS PER SECOND.                              00063410
C                                                                          00063420
C     OUTPUT VIA COMMON                                                    00063430
C                                                                          00063440
C     REFERENCE                                                            00063450
C           DIRK BROUWER - SOLUTION OF THE PROBLEM OF ARTIFICIAL           00063460
C                          SATELLITE THEORY WITHOUT DRAG -                 00063470
C           THE ASTRONOMICAL JOURNAL, VOL.  64, NO.  9,                    00063480
C           NOVEMBER 1959, PAGES 378 - 397                                 00063490
C                                                                          00063500
C     METHOD                                                               00063510
C           REFER TO MATHEMATICAL DESCRIPTION IN SUBPROGRAM WRITEUP         00063520
C                                                                          00063530
C     RESTRICTIONS                                                         00063540
C           ******                                                         00063550
C                                                                          00063560
C     ACCURACY                                                             00063570
C                                                                          00063580
C     REQUIRED SUBPROGRAMS                                                 00063590
C           KOMEAN                                                         00063600
C                                                                          00063610
C                                                                          00063620
C     TIMING                                                               00063630
C           NO ESTIMATE AVAILABLE                                          00063640
C                                                                          00063650
C                                                                          00063660
C                                                                          00063670
C                                                                          00063680
C***** START PROGRAM ***************************************************00063690
C                                                                          00063700
ISN 0006      1000 FORMAT(1H1)                                             00063710
ISN 0007      1001 FORMAT(1X,61HINTERMEDIATE OUTPUT FROM BRWR1:ARRAYS A110,B,C,D,EL,  00063720
             1F,G,GP,S,A2,A3)                                              00063730
ISN 0008      1002 FORMAT(6(1X,D21.14))                                    00063740
ISN 0009      1003 FORMAT(72X)                                             00063750
ISN 0010           DIMENSION DUM1(100) ,DUM2(49)                          00063760
ISN 0011           DIMENSION A110(6),GP(5),A11(6),A1(6),A(6),RX(3),VX(3),EL(13),F(9),00063770
             1E(9),C(10),D(23),G(13),X(28),S(3)                            00063780
ISN 0012           DIMENSION T0(99),ARG0(99),ARGMOT(99),ARG(99),CCOEF(99,6),  00063790
             1SCOEF(99,6),DSUP(6),ASHORT(6)                                00063800
C                                                                          00063810
ISN 0013           COMMON DUM1,A110,GP,ERR,A11,A1,A,RX,VX,ENO,ECA1 D,E,DII,ALI,UL,  00063820
             1  GI,UG,HI,UH,S,EL,A2,A3,B,C,D,G,X,F,DUM2,CMU,               00063830
             2                          T0,DJ0,DTIMES,ARG0,ARGMOT,ARG,CCOEF,  00063840
             3SCOEF,DSUP,CJ2S,CJ3,CJ4,DLJ2S,DLJ3,DLJ4,DLSUM,DAJ2S,DAJ3,DAJ4,  00063850
             4DASUM,REM , ASHORT,                                          00063860
             5           NBRWR1,NLONG,NSHORT,NSEC,NSECD,NSUPP,NSUPPD,NARG,KCOUNT00063870
             6,NKOZ,NKOZD                                                  00063880
C                                                                          00063890
C     COMPUTE INTERMEDIATE QUANTITIES                                      00063900
C                                                                          00063910
ISN 0014         5 A2=A110(1)**2                                           00063920
ISN 0015         6 A3=A110(1)*A2                                           00063930
ISN 0016           F(1) = A110(2)                                          00063940
ISN 0017         7 F(2)=A110(2)*A110(2)                                    00063950
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ISN 0018          8 F(3)=F(2)+F(2)                                                                                00063960
ISN 0019          9 F(4)=F(2)+F(3)                                                                                00063970
ISN 0020         10 F(5)=9.D0*F(2)                                                                                00063980
ISN 0021         11 F(6)=4.D0+F(4)                                                                                00063990
ISN 0022         12 F(7)=2.D0+F(2)                                                                                00064000
ISN 0023         13 B(1)=1.D0-F(2)                                                                                00064010
ISN 0024         14 B(2)=DSQRT(B(1))                                                                              00064020
ISN 0025         15 B(3)=B(1)*B(2)                                                                                00064030
ISN 0026         16 B(4)=B(3)*B(3)                                                                                00064040
ISN 0027         17 B(5)=9.D0*B(1)                                                                                00064050
ISN 0028         18 B(6)=25.D0*B(1)                                                                               00064060
ISN 0029         19 B(7)=126.D0*B(1)                                                                              00064070
ISN 0030         20 B(8)=1.D0/B(3)                                                                                00064080
ISN 0031         21 B(9)=1.D0/(B(1)*B(1))                                                                         00064090
ISN 0032         22 D(1)=DCOS(A110(3))                                                                            00064100
ISN 0033         23 D(2)=D(1)+D(1)                                                                                00064110
ISN 0034         24 D(3)=D(1)*D(1)                                                                                00064120
ISN 0035         25 D(4)=D(3)*D(3)                                                                                00064130
ISN 0036         26 C(1)=GP(2)/A2                                                                                 00064140
ISN 0037         27 C(2)=1.5D0*C(1)*B(9)                                                                          00064150
ISN 0038         28 C(3)=.41666667D-1*C(2)*C(2)                                                                   00064160
ISN 0039         29 C(4)=.937D0*GP(4)/(A2*A2*B(1)*B(4))                                                           00064170
ISN 0040         30 C(5)=.83333333D-1*C(2)                                                                        00064180
ISN 0041         31 C(6)=.41666667D0*C(4)/C(2)                                                                    00064190
ISN 0042         32 C(7)=.25D0*GP(3)/(GP(2)*A110(1)*B(1))                                                         00064200
ISN 0043         33 C(8)=.4375D0*GP(5)/(GP(2)*A3*B(4))                                                            00064210
ISN 0044         34 C(9)=.16666667D0*C(2)                                                                         00064220
ISN 0045         35 C(10)=C(9)*D(2)                                                                               00064230
ISN 0046         36 D(5)=1.5D0-D(3)                                                                               00064240
ISN 0047         37 D(6)=3.D0*D(3)-1.D0                                                                           00064250
ISN 0048         38 D(7)=5.D0*D(3)-1.D0                                                                           00064260
ISN 0049         39 D(8)=8.D0*D(4)/D(7)                                                                           00064270
ISN 0050         40 D(9)=5.D0*D(8)/D(7)                                                                           00064280
ISN 0051         41 D(10)=D(8)-D(6)                                                                               00064290
ISN 0052         42 D(11)=C(5)*(5.D0*D(10)-4.D0+4.D0*D(3))-C(6)*D(10)                                             00064300
ISN 0053         43 D(12)=.16666667D0*C(6)*(3.D0*D(10)-2.D0)                                                      00064310
ISN 0054         44 D(13)=.19444444D0*C(8)*(D(10)+D(10)-D(5))                                                     00064320
ISN 0055         45 D(14)=3.D0-16.D0*D(3)/D(7)+D(9)                                                               00064330
ISN 0056         46 D(15)=C(8)*D(14)                                                                              00064340
ISN 0057         47 D(16)=F(6)*D(15)                                                                              00064350
ISN 0058         48 D(17) = 0.33333333D0*D(13)                                                                    00064360
ISN 0059         49 D(18)=.12962963D0*(D(15)+D(15)-C(8))                                                          00064370
ISN 0060         50 D(19)=3.D0*D(5)                                                                               00064380
ISN 0061         51 D(20)=D(6)*D(6)                                                                               00064390
ISN 0062         52 D(21)=2.D0-D(7)                                                                               00064400
ISN 0063         53 D(22)=C(10)*DSQRT(D(5))                                                                       00064410
ISN 0064         54 D(23)=4.D0*C(4)*D(5)                                                                          00064420
ISN 0065         55 F(8)=D(3)*(2.D0+F(4))                                                                         00064430
ISN 0066         56 F(9)=(2.D0+5.D0*F(2))*D(8)-D(9)*F(3)*D(3)                                                     00064440
ISN 0067         57 G(1)=DSIN(A110(3))                                                                            00064450
ISN 0068         58 G(2)=G(1)*G(1)                                                                                00064460
ISN 0069         59 G(3)=A110(2)*D(1)                                                                             00064470
ISN 0070         60 G(4)=G(3)*D(1)                                                                                00064480
ISN 0071         61 G(5)=G(3)/G(1)                                                                                00064490
ISN 0072         62 G(6)=G(4)/G(1)                                                                                00064500
ISN 0073         63 G(7)=B(1)*G(1)                                                                                00064510
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ISN 0074          64 G(8)=G(7)/A110(2)                                                  00064520
ISN 0075          65 G(9)=A110(2)*G(1)                                                  00064530
ISN 0076          66 G(10)=G(3)*G(3)                                                    00064540
ISN 0077          67 G(11)=B(1)/A110(2)                                                 00064550
ISN 0078          68 G(12)=.5D0*G(11)                                                   00064560
ISN 0079          69 G(13)=G(11)*C(9)                                                   00064570
                C                                                                     00064580
                C     COMPUTE *MEAN* MEAN MOTION                                      00064590
                C                                                                     00064600
ISN 0080          70 ENO=DSQRT(GP(1)/A3)                                              00064610
                C                                                                     00064620
                C     COMPUTE COEFFICIENTS OF SECULAR TERMS                           00064630
                C                                                                     00064640
ISN 0081          71 S(1)=ENO*(1.D0+H(2)*(C(2)*D(6)+C(3)*(16.D0*B(2)-15.D0+B(6))+(30.D0-00064650
                  196.D0*B(2)-90.D0*B(1))*D(3)+(105.D0+144.D0*B(2)+B(6))*D(4))+C(4)*F00064660
                  2(2)*(3.D0-30.D0*D(3)+35.D0*D(4))))                                 00064670
ISN 0082          72 S(2)=E.DA(C(2)*B(7)+C(3)*(24.DC*B(2)-35.D0+B(6)+(90.DC-192.D0*B(2)00064680
                  1-B(7))- D(3)+(385.D0+360.D0*B(2)+45.DC*B(1))*D(4))+.33333333D0*C(400064690
                  2)*(21.D0-B(5)+    (B(7)-270.D0)*D(3)+(385.D0-189.D0*B(1))*D(4)))  00064700
ISN 0083          73 S(3)=ENO*(4.D0*D(1)*(C(3)*(B(5)-5.D0+12.D0*B(2)-D(3)*(35.D0+36.D0*00064710
                  1B(2)+5.C0*  B(1)))+.33333333D0*C(4)*(5.D0-3.D0*B(1))*(3.D0-7.D0*D(00064720
                  *3)))-C(2)*D(2))                                                    00064730
ISN 0084           IF(NKOZ)8000,74,8000                                               00064740
ISN 0085       8000 CALL KOMEAN(DN)                                                   00064750
ISN 0086           S(1)=S(1)+DN                                                       00064760
                C                                                                     00064770
                C     COMPUTE COEFFICIENTS OF LONG PERIOD TERMS                       00064780
                C                                                                     00064790
ISN 0087          74 EL(1)=B(3)*G(11)                                                 00064800
ISN 0088          75 EL(2)=B(2)*G(8)*(-C(7)-(4.DC+F(5))*D(12))                        00064810
ISN 0089          76 EL(3)=G(9)*B(3)*D(13)                                            00064820
ISN 0090          77 EL(4)=.5D0*C(6)*(F(7)-3.D0*F(8)+F(9))-.41666667D-1*C(2)*(F(7)-11.D00064830
                  10*    F(8)+5.D0*F(9))                                            00064840
ISN 0091          78 EL(5)=C(7)*(G(1)/F(1)-G(6))+D(12)*((G(8)-G(6))*F(6)+G(9)*(26.0D0+ 00064850
                  1  F(5)))-G(4)*G(1)*D(16)                                         00064860
ISN 0092          79 EL(6)=G(9)*(D(18)*G(10)-D(17)*(3.0D0+F(3)-G(10)/G(2)))           00064870
ISN 0093          80 EL(7)=G(3)*A110(2)*(C(6)*D(14)-C(5)*(5.D0*D(14)-4.D0))           00064880
ISN 0094          81 EL(8)=G(5)*(C(7)+F(6)*D(12)+G(2)*D(16))                          00064890
ISN 0095          82 EL(9)=G(5)*F(2)*(-D(17)-D(18)*G(2))                              00064900
ISN 0096          83 EL(10)=B(1)*F(1)*C(11)                                           00064910
ISN 0097          84 EL(11)=G(7)*(C(7)+F(6)*D(12))                                    00064920
ISN 0098          85 EL(12)=-F(2)*G(7)*D(13)                                          00064930
ISN 0099          86 EL(13)=-G(3)/G(7)                                                00064940
ISN 0100           IF(NBR*R1)89,87,89                                                 00064950
ISN 0101          89 WRITE(6,1000)                                                    00064960
ISN 0102           WRITE(6,1001)                                                      00064970
ISN 0103           WRITE(6,1002)(A110(J),J=1,6)                                       00064980
ISN 0104           WRITE(6,1003)                                                      00064990
ISN 0105           WRITE(6,1002)( B(J),J=1, 9)                                        00065000
ISN 0106           WRITE(6,1003)                                                      00065010
ISN 0107           WRITE(6,1002)( C(J),J=1,10)                                        00065020
ISN 0108           WRITE(6,1003)                                                      00065030
ISN 0109           WRITE(6,1002)( D(J),J=1,23)                                        00065040
ISN 0110           WRITE(6,1003)                                                      00065050
ISN 0111           WRITE(6,1002)(EL(J),J=1,13)                                        00065060
ISN 0112           WRITE(6,1003)                                                      00065070
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ISN 0113          WRITE(6,1002)( F(J),J=1, 9)                    00065080
ISN 0114          WRITE(6,1003)                                  00065090
ISN 0115          WRITE(6,1002)( G(J),J=1,13)                    00065100
ISN 0116          WRITE(6,1003)                                  00065110
ISN 0117          WRITE(6,1002)(GP(J),J=1, 5)                    00065120
ISN 0118          WRITE(6,1003)                                  00065130
ISN 0119          WRITE(6,1002)( S(J),J=1, 5)                    00065140
ISN 0120          WRITE(6,1003)                                  00065150
ISN 0121          WRITE(6,1002)A2,A3                             00065160
ISN 0122          WRITE(6,1000)                                  00065170
ISN 0123       87 RETURN                                         00065180
ISN 0124          END                                            00065190
```

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS																		
A	0011	0013																	
B	0011	0013	0023	0024	0024	0025	0025	0025	0026	0026	0026	0027	0027	0028	0028	0029	0029	0030	0030
	0031	0031	0031	0037	0039	0039	0042	0043	0073	0077	0081	0081	0081	0081	0081	0081	0081	0082	0082
	0082	0082	0082	0082	0082	0082	0082	0083	0083	0083	0083	0083	0087	0088	0089	0096	0105		
C	0011	0013	0036	0037	0037	0038	0038	0038	0039	0040	0040	0041	0041	0041	0042	0043	0044	0044	0045
	0045	0052	0052	0053	0054	0056	0059	0063	0064	0079	0081	0081	0081	0082	0082	0082	0083	0083	0083
	0088	0090	0090	0091	0093	0093	0094	0097	0107										
D	0011	0013	0032	0033	0033	0033	0034	0034	0034	0035	0035	0035	0045	0046	0046	0047	0047	0048	0048
	0049	0049	0049	0050	0050	0050	0051	0051	0051	0052	0052	0052	0052	0053	0053	0054	0054	0054	0054
	0055	0055	0055	0055	0056	0056	0057	0057	0058	0058	0059	0059	0059	0060	0060	0061	0061	0061	0062
	0062	0063	0063	0064	0064	0065	0066	0066	0066	0069	0070	0081	0081	0081	0081	0081	0082	0082	0082
	0082	0082	0083	0083	0083	0083	0087	0088	0089	0091	0091	0092	0092	0093	0093	0093	0094	0095	0095
	0096	0097	0098	0109															
F	0011	0013	0016	0017	0018	0018	0018	0019	0019	0019	0020	0020	0021	0021	0022	0022	0023	0057	0065
	0065	0066	0066	0066	0081	0088	0090	0090	0090	0090	0090	0090	0091	0091	0091	0092	0094	0095	0096
	0097	0098	0113																
G	0011	0013	0067	0068	0068	0068	0069	0070	0070	0071	0071	0071	0072	0072	0072	0073	0073	0074	0074
	0075	0075	0076	0076	0076	0077	0078	0078	0079	0079	0088	0089	0091	0091	0091	0091	0091	0091	0091
	0092	0092	0092	0092	0093	0094	0094	0095	0095	0097	0098	0099	0099	0115					
J	0103	0103	0103	0105	0105	0105	0107	0107	0107	0109	0109	0109	0111	0111	0111	0113	0113	0113	0115
	0115	0115	0117	0117	0117	0119	0119	0119											
S	0011	0013	0081	0082	0083	0086	0086	0119											
X	0011	0013																	
A1	0011	0013																	
A2	0013	0014	0015	0036	0039	0039	0121												
A3	0013	0015	0043	0060	0121														
DN	0002	0085	0086																
EL	0011	0013	0087	0088	0089	0090	0091	0092	0093	0094	0095	0096	0097	0098	0099	0111			
GP	0011	0013	0036	0039	0042	0042	0043	0043	0080	0117									
G1	0013																		
H1	0013																		
RX	0011	0013																	
T0	0012	0013																	
UG	0013																		
UH	0013																		
UL	0013																		
VX	0011	0013																	
AL1	0013																		
ARG	0012	0013																	
A11	0011	0013																	
CJ3	0013																		
CJ4	0013																		
CMU	0013																		
DJC	0013																		
DIE	0013																		
DII	0013																		
ENO	0013	0080	0081	0082	0083														
ERR	0013																		
REM	0013																		
ARG0	0012	0013																	
A11C	0011	0013	0014	0015	0016	0017	0017	0032	0042	0067	0069	0074	0075	0077	0093	0103			
CJ25	0013																		
DAJ3	0013																		
DAJ4	0013																		

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS		
DCOS	0032		
DLJ3	0013		
DLJ4	0013		
DSIN	0067		
DSUP	0012	0013	
DUM1	0010	0013	
DUM2	0010	0013	
ECA1	0013		
NARG	0013		
NKOZ	0013	0084	
NSEC	0013		
BRWR1	0002		
CCOEF	0012	0013	
CAJ2S	0013		
DASUM	0013		
DLJ2S	0013		
DLSUM	0013		
DSQRT	0024	0063	0080
NKOZD	0013		
NLONG	0013		
NSECD	0013		
NSUPP	0013		
SCOEF	0012	0013	
ARGMOT	0012	0013	
ASHORT	0012	0013	
CTIMES	0013		
KCOUNT	0013		
KOMEAN	0085		
NBRWR1	0013	0100	
NSHORT	0013		
NSUPPD	0013		

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
1	0005	
5	0014	
6	0015	
7	0017	
8	0018	
9	0019	
10	0020	
11	0021	
12	0022	
13	0023	
14	0024	
15	0025	
16	0026	
17	0027	
18	0028	
19	0029	
20	0030	
21	0031	
22	0032	
23	0033	
24	0034	
25	0035	
26	0036	
27	0037	
28	0038	
29	0039	
30	0040	
31	0041	
32	0042	
33	0043	
34	0044	
35	0045	
36	0046	
37	0047	
38	0048	
39	0049	
40	0050	
41	0051	
42	0052	
43	0053	
44	0054	
45	0055	
46	0056	
47	0057	
48	0058	
49	0059	
50	0060	
51	0061	
52	0062	
53	0063	
54	0064	
55	0065	
56	0066	
57	0067	

*****F O R T R A N C R O S S R E F E R E N C E L I S T I N G*****

LABEL	DEFINED	REFERENCES									
58	0068										
59	0069										
60	0070										
61	0071										
62	0072										
63	0073										
64	0074										
65	0075										
66	0076										
67	0077										
68	0078										
69	0079										
70	0080										
71	0081										
72	0082										
73	0083										
74	0087	0084									
75	0088										
76	0089										
77	0090										
78	0091										
79	0092										
80	0093										
81	0094										
82	0095										
83	0096										
84	0097										
85	0098										
86	0099										
87	0123	0100									
89	0101	0100	0100								
1000	0006	0101	0122								
1001	0007	0102									
1002	0008	0103	0105	0107	0109	0111	0113	0115	0117	0119	0121
1003	0009	0104	0106	0108	0110	0112	0114	0116	0118	0120	
2001	0004										
8000	0085	0084	0084								

```
        COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
              CSUBROUTINE BRWR2                                                                    00065200
ISN 0002            SUBROUTINE BRWR2  (/DT/,      E,FAN,RADV,GDIF,NMAX,NIT)                      00065210
ISN 0003            IMPLICIT REAL*8(A-H,O-Z,$)                                                   00065220
                    C                                                                            00065230
                    C     VERSION OF 01/31/64                                                    00065240
                    C           FORTRAN SUBROUTINE                                               00065250
                    C                                                                            00065260
                    C     PURPOSE                                                                00065270
                    C           COMPUTES THE VALUES OF THE OSCULATING ELEMENTS AND THE           00065280
                    C           POSITION-VELOCITY VECTOR FOR ANY TIME.                           00065290
                    C           THE SHORT-PERIOD PERTURBATIONS ARE COMPUTED WITH E" AND I".       00065300
                    C                                                                            00065310
                    C     DUM1 IS A DUMMY VARIABLE INSERTED AS FIRST VARIABLE IN COMMON IN       00065320
                    C     BRWR1,BRWR2,AND BRWR4 TO PERMIT SHIFTING OF VARIABLES IN COMMON        00065330
                    C     AREA IF DESIRED. THE DIMENSION OF DUM1 MAY BE CHANGED BUT SHOULD       00065340
                    C     BE THE SAME IN SUBROUTINES BRWR1,BRWR2,AND BRWR4,AND THE CALLING       00065350
                    C     PROGRAM.                                                               00065360
                    C                                                                            00065370
                    C     CALLING SEQUENCE                                                       00065380
                    C                 CALL BRWR2(DT,E,FAN,RADV,GDIF,NMAX,NIT)                    00065390
                    C                                                                            00065400
                    C     INPUT                                                                  00065410
                    C           DT    = TIME ELAPSED FROM EPOCH OF MEAN ELEMENTS - SECONDS       00065420
                    C           NMAX  = MAXIMUM NUMBER OF ITERATIONS ALLOWED                     00065430
                    C                   SEE SUBROUTINE BRWR1 FOR INPUT VIA COMMON                00065440
                    C                                                                            00065450
                    C     OUTPUT                                                                 00065460
                    C           E     = ECCENTRIC ANOMALY                        RADIANS         00065470
                    C           FAN   = TRUE ANOMALY                             RADIANS         00065480
                    C           RADV  = RADIUS VECTOR                            KILOMETERS      00065490
                    C           GDIF  = LAST CORRECTION (E2-E1)/E2                               00065500
                    C                   IN SOLVING KEPLER'S EQUATION.                            00065510
                    C           NIT   = SERIAL NUMBER OF CURRENT ITERATION IN SOLVING            00065520
                    C                   KEPLER'S EQUATION                                        00065530
                    C                                                                            00065540
ISN 0004             1000 CONTINUE                                                               00065550
                    C     OUTPUT VIA COMMON                                                      00065560
                    C           OSCULATING ORBITAL ELEMENTS AT TIME T = EPOCH TIME + DT           00065570
                    C                                                                            00065580
                    C           A(1) = SEMI-MAJOR AXIS                    - KILOMETERS           00065590
                    C           A(2) = ECCENTRICITY                       - DIMENSIONLESS        00065600
                    C           A(3) = INCLINATION                        - RADIANS              00065610
                    C           A(4) = RIGHT ASCENSION OF ASCENDING NODE  - RADIANS              00065620
                    C           A(5) = ARGUMENT OF PERIGEE                - RADIANS              00065630
                    C           A(6) = MEAN ANOMALY                       - RADIANS              00065640
                    C                                                                            00065650
                    C     REQUIRED SUBPROGRAMS                                                   00065660
                    C                 ADLH                                                       00065670
                    C           07/22/63  ALLOT                                                  00065680
                    C           03/03/64  ATANQ                                                  00065690
                    C           03/02/64  ELRV                                                   00065700
                    C                     SUPP1                                                  00065710
                    C           09/12/63  XKEP                                                   00065720
                    C                                                                            00065730
```

```
                C                                                                       00065740
                C      TIMING                                                           00065750
                C            NO ESTIMATE AVAILABLE                                      00065760
                C                                                                       00065770
                C                                                                       00065780
                C      PROGRAM MODIFICATIONS                                            00065790
                C                                                                       00065800
                C                                                                       00065810
                C      STATEMENT A1(1)=A11(1) ADDED 7/26/68                             00065820
                C                                                                       00065830
                C***** START PROGRAM ***************************************************00065840
                C                                                                       00065850
ISN 0005              DIMENSION DUM1(10C)                                               00065860
ISN 0006              DIMENSION A110(6),GP(5),A11(6),A1(6),A(6),RX(3),VX(3),EL(13),F(9),00065870
                     1    B(9),C(10),D(23),G(13),X(28),S(3)                           00065880
ISN 0007              DIMENSION AG(6),D1(6),D2(6),D3(6)  ,AIDH(24)                      00065890
ISN 0008              DIMENSION T0(99),ARG0(99),ARGMOT(99),ARG(99),CCOEF(99,6),        00065900
                     1SCOEF(99,6),DSUP(6),ASHORT(6),DADLH(19)                          00065910
                C                                                                       00065920
ISN 0009              COMMON DUM1,A110,GP,ERR,A11,A1,A,RX,VX,ENO,ECA1,D1E,D1I,AL1,UL,   00065930
                     1  G1,UG,H1,UH,S,EL,A2,A3,B,C,D,G,X,F,                           00065940
                     1CONV,AIDH,AG,D1,D2,D3 ,CMU,T0,DJ0,DTIMES,ARG0,ARGMOT,ARG,CCOEF, 00065950
                     3SCOEF,DSUP,CJ2S,CJ3,CJ4,DLJ2S,DLJ3,DLJ4,DLSUM,DAJ2S,DAJ3,DAJ4,   00065960
                     4DASUM,REM , ASHORT                                               00065970
                     5          NBRWR1,NLONG,NSHORT,NSEC,NSECD,NSUPP,NSUPPD,NARG,KCOUNTC0065980
                     6,NKOZ,NKOZD                                                      00065990
ISN 0010       1850 FORMAT(//29X,74HCONTRIBUTION OF J2 SQUARE, J3 , J4 TO SECOND ORDER00066000
                     1 SHORT PERIOD TERMS IN A/  39X,3(F15.7,3X)///)                   00066010
                C                                                                       00066020
ISN 0011              DASUM=0.D 00                                                      00066030
ISN 0012              DO 700 I=1,6                                                      00066040
ISN 0013         700  DSUP(I)=0.D 00                                                    00066050
                C     COMPUTE SECULAR TERMS                                             00066060
                C                                                                       00066070
ISN 0014              S1 = S(1)                                                         00066080
ISN 0015              S2 = S(2)                                                         00066090
ISN 0016              S3 = S(3)                                                         00066100
ISN 0017              DS1 = S1                                                          00066110
ISN 0018              DS2 = S2                                                          00066120
ISN 0019              DS3=S3                                                            00066130
ISN 0020              AG(1)=A110(1)                                                     00066140
ISN 0021              AG(2)=A110(2)                                                     00066150
ISN 0022              AG(3)=A110(3)                                                     00066160
ISN 0023              AG(4)=A110(4) +DS3*DT                                             00066170
ISN 0024              AG(5)=A110(5) +DS2*DT                                             00066180
ISN 0025              AG(6)=A110(6) +DS1*DT                                             00066190
ISN 0026              AG4=AG(4)                                                         00066200
ISN 0027              AG5=AG(5)                                                         00066210
ISN 0028              AG6=AG(6)                                                         00066220
ISN 0029              AG(4)=ALLOT (AG4)                                                 00066230
ISN 0030              AG(5)=ALLOT (AG5)                                                 00066240
ISN 0031              AG(6)=ALLOT (AG6)                                                 00066250
ISN 0032              D1(1)=DT*AIDH(7)*1.D 00/3.6D 00                                   00066260
ISN 0033              D1(2)=DT*AIDH(8)/3.6D 03                                          00066270
ISN 0034              DO 1002 I=3,6                                                     00066280
ISN 0035        1002  D1(I)=DT*AIDH(I+6)/(CONV*3.6D 03)                                 00066290
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ISN 0036          D2(1)=DT**2*AIDH(13)/1.296D 04                                    00066300
ISN 0037          D2(2)=DT**2*AIDH(14)/1.296D 07                                    00066310
ISN 0038          DO 1003 I=3,6                                                     00066320
ISN 0039       1003 D2(I)=DT**2*AIDH(I+12)/(CONV*1.296D 07)                         00066330
                C     TO ALLOW FOR THE FACT THAT AIDH(I),I=13,18 ARE PER (100HRS)SQUAREDC0066340
ISN 0040          DO 1013 I=1,6                                                     00066350
ISN 0041       1013 D2(I)=1.D-04*D2(I)                                              00066360
ISN 0042          D3(1)=DT**3*AIDH(19)/4.6656D 07                                   00066370
ISN 0043          D3(2)=DT**3*AIDH(20)/4.6656D 10                                   00066380
ISN 0044          DO 1004 I=3,6                                                     00066390
ISN 0045       1004 D3(I)=DT**3*AIDH(I+18)/(CONV*4.6656D 10)                        00066400
                C     TO ALLOW FOR THE FACT THAT AIDH(I),I=19,24 ARE PER (100HRS)CUBED  00066410
ISN 0046          DO 1014 I=1,6                                                     00066420
ISN 0047       1014 D3(I)=1.D-06*D3(I)                                              00066430
ISN 0048          DO 1005 I=1,6                                                     00066440
ISN 0049       1005 A11(I)=AG(I)+DF(I)+D2(I)+D3(I)                                  00066450
ISN 0050          A114=A11(4)                                                       00066460
ISN 0051          A115=A11(5)                                                       00066470
ISN 0052          A116=A11(6)                                                       00066480
ISN 0053             9 A11(6) = ALLOT (A116)                                        00066490
ISN 0054            10 A11(5) = ALLOT (A115)                                        00066500
ISN 0055            11 A11(4) = ALLOT (A114)                                        00066510
                C     COMPUTE LONG PERIOD TERMS                                   00066520
                C                                                                 00066530
ISN 0056            15 X(1)=A11(5)+A11(5)                                         00066540
ISN 0057            16 X(2)=X(1)+A11(5)                                           00066550
ISN 0058            17 X(3)=DSIN(X(1))                                            00066560
ISN 0059            18 X(4)=DCOS(A11(5))                                          00066570
ISN 0060            19 X(5)=DCOS(X(2))                                            00066580
ISN 0061            20 A1(6)=A11(6)+EL(1)*X(3)+EL(2)*X(4)+EL(3)*X(5)              00066590
ISN 0062            21 A1(5)=A11(5)+EL(4)*X(3)+EL(5)*X(4)+EL(6)*X(5)              00066600
ISN 0063            22 A1(4)=A11(4)+EL(7)*X(3)+EL(8)*X(4)+EL(9)*X(5)              00066610
ISN 0064            23 D1E=EL(10)*DCOS(X(1))+EL(11)*DSIN(A11(5))+EL(12)*DSIN(X(2))00066620
ISN 0065            24 D1I=EL(13)*D1E                                             00066630
ISN 0066            25 A1(3)=A11(3)+D1I                                           00066640
ISN 0067            26 A1(2)=A11(2)+D1E                                           00066650
ISN 0068               A1(1)=A11(1)                                               00066660
ISN 0069            28 AL1=ALLOT(A1(6))                                           00066670
ISN 0070            29 G1 =ALLOT(A1(5))                                           00066680
ISN 0071            30 H1 =ALLOT(A1(4))                                           00066690
                C     TO WRITE LONG PERIOD TERMS                                  00066700
                C                                                                 00066710
                C     COMPUTE SHORT PERIOD TERMS                                  00066720
                C                                                                 00066730
ISN 0072            31 ECA1=XKEP(AL1,A11C(2),X(6),X(7),ERR,GDIF,NMAX,NIT)         00066740
ISN 0073            33 X(8)=1.DO-A110(2)*X(7)                                     00066750
ISN 0074            34 X(9)=1.DO/X(8)                                             00066760
ISN 0075            35 X(10)=X(9)*X(9)                                            00066770
ISN 0076            36 X(11)=X(9)*X(10)                                           00066780
ISN 0077            37 X(12)=X(6)*X(9)*B(2)                                       00066790
ISN 0078            38 X(13)=X(9)*(X(7)-A110(2))                                  00066800
ISN 0079               X12 = X(12)                                                00066810
ISN 0080               DX12 = X12                                                 00066820
ISN 0081               X13 = X(13)                                                00066830
ISN 0082               DX13 = X13                                                 00066840
ISN 0083               X(14) = ATAN2(DX12,DX13)                                   00066850
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ISN 0084        40 X(15)=G1+G1                                                          00066860
ISN 0085        41 X(16)=X(15)+X(14)                                                    00066870
ISN 0086        42 X(17)=X(16)+X(14)                                                    00066880
ISN 0087        43 X(18)=X(17)+X(14)                                                    00066890
ISN 0088        44 X(19)=DSIN(X(16))                                                    00066900
ISN 0089        45 X(20)=DSIN(X(18))                                                    00066910
ISN 0090        46 X(21)=DCOS(X(17))                                                    00066920
ISN 0091        47 X(22)=D(6)*(X(11)-B(8))                                              00066930
ISN 0092        48 X(23)=D(19)*X(21)                                                    00066940
ISN 0093        49 X(24)=A110(2)*(3.D0*DCOS(X(16))+DCOS(X(18)))                         00066950
ISN 0094        50 X(25)=X(9)+B(1)*X(10)                                                00066960
ISN 0095        51 X(26)=G(13)*(D(20)*X(12)*(X(25)+1.D0)+D(19)*((1.D0-X(25))*X(19)+     00066970
                  1     (X(25)+.33333333D0)*X(20)))                                   00066980
ISN 0096        52 X(27)=6.D0*(X(14)-AL1+A110(2)*X(12))                                 00066990
ISN 0097        53 X(28)=3.D0*(DSIN(X(17))+A110(2)*X(19))+A110(2)*X(20)                 00067000
                C                                                                       00067010
                C     COMPUTE OSCULATING ELEMENTS                                       00067020
                C                                                                       00067030
ISN 0098        54 A(1)=A110(1)*(1.D0+C(1)*(X(22)+X(11)*X(23)))                         00067040
ISN 0099        55 A(2)= A110(2)+D1E4G(12)*(C(1)*(X(22)+X(23)*(X(11)-B(9)))-D(23)*      00067050
                  1X(24))                                                               00067060
ISN 0100        56 A(3)=A110(3)+D11+C(22)*(3.D0*X(21)+X(24))                            00067070
ISN 0101        57 UL= AL1-B(2)*X(26)                                                   00067080
ISN 0102        58 UG= G1+X(26)+C(9)*(D(7)*X(27)+D(21)*X(28))                           00067090
ISN 0103        59 UH= H1-C(10)*(X(27)-X(28))                                           00067100
ISN 0104        60 A(6)=ALLOT(UL)                                                       00067110
ISN 0105        61 A(5)=ALLOT(UG)                                                       00067120
ISN 0106        62 A(4)=ALLOT(UH)                                                       00067130
ISN 0107           DO 6220 I=1,6                                                        00067140
ISN 0108      6220 ASHORT(I)=A(1)                                                       00067150
ISN 0109           IF(NSEC)6200,6210,6200                                               00067160
ISN 0110      6200 TH=DCOS(A1(3))                                                       00067170
ISN 0111           ECC=A1(2)                                                            00067180
ISN 0112           GPRIME=A1(5)                                                         00067190
ISN 0113           APRIME=A1(1)*1.D-CJ/REM                                              00067200
ISN 0114           EPRIME=ECA1                                                          00067210
ISN 0115           U=DSQRT((1.D 00+A1(2))/(1.D 00-A1(2)))*DTAN(ECA1/2.D 00)             00067220
ISN 0116           FPRIME=2.D 00*DATAN(U)                                               00067230
ISN 0117           RA=1.D 00-A1(2)*DCOS(ECA1)                                           00067240
ISN 0118           RPRIME=RA*APRIME                                                     00067250
ISN 0119           ET=DSQRT(RA*(1.D 00+A1(2)*DCOS(FPRIME)))                             00067260
ISN 0120           CAPL=DSQRT(CMU*APRIME)                                               00067270
ISN 0121           CAPG=CAPL*DSQRT(1.D 00-A1(2)**2)                                     00067280
ISN 0122           CALL ADLH(DLJ2S,DLJ3,DLJ4,DLSUM,                                     00067290
                  1           TH,ECC,GPRIME,APRIME,RPRIME,ET,FPRIME,CAPG,CAPL,CMU,    00067300
                  2CJ2S,CJ3,CJ4,DADLH)                                                  00067310
ISN 0123      1828 FORMAT(6(1X,D21.14))                                                 00067320
ISN 0124      1860 FORMAT(  1X,4HADLH)                                                  00067330
ISN 0125           IF(KCOUNT)2000,2002,2000                                             00067340
ISN 0126      2002 IF(NSECU)2001,2000,2001                                              00067350
ISN 0127      2001 WRITE(6,1860)                                                        00067360
ISN 0128           WRITE(6,1828)(DADLH(I),I=1,19)                                       00067370
ISN 0129           WRITE(6,1828)DLJ2S,DLJ3,DLJ4,DLSUM,TH,ECC,GPRIME,APRIME,RPRIME,ET,00067380
                  1FPRIME,CAPG,CAPL,CMU,CJ2S,CJ3,CJ4                                    00067390
ISN 0130      2000 DAJ2S=2.D CC*CAPL*REM*DLJ2S                                          00067400
ISN 0131           DAJ3 =2.D C0*CAPL*REM*DLJ3                                           00067410
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ISN 0132            DAJ4 =2.D 00*CAPL*REM*DLJ4                                    00067420
ISN 0133            DASUM=2.D 00*CAPL*REM*DLSUM                                   00067430
ISN 0134            A(1)=A(1)+DASUM*1.D 03                                        00067440
ISN 0135            IF(KCOUNT)6210,8299,6210                                      00067450
ISN 0136         8299 IF(NSECS)8300,6210,8300                                     00067460
ISN 0137         8300 WRITE(6,1850)DAJ2S,DAJ3,DAJ4                                00067470
ISN 0138         6210 IF(NSUPP)621,63,621                                         00067480
ISN 0139          621 CALL SUPP1                                                  00067490
ISN 0140            A(1)=A(1)+DSUP(1)*1.D 03                                      00067500
ISN 0141            A(2)=A(2)+DSUP(2)                                             00067510
ISN 0142            DO 629 I=3,6                                                  00067520
ISN 0143          629 A(I)=A(I)+DSUP(I)/CONV                                      00067530
                  C                                                             00067540
                  C     COMPUTE POSITION AND VELOCITY COMPONENTS                00067550
                  C                                                             00067560
ISN 0144           63 CALL ELRV (RX,VX,E,FAN,RADV,A,P,EN,GP(1),ERR,GDIF,NMAX,NIT) 00067570
ISN 0145            RETURN                                                      00067580
ISN 0146            END                                                         00067590
```

****FORTRAN CROSS REFERENCE LISTING****

SYMBOL	INTERNAL STATEMENT NUMBERS																	
A	0006	0009	0098	0099	0100	0104	0105	0106	0108	0134	0134	0140	0140	0141	0141	0143	0143	0144
B	0006	0009	0077	0091	0094	0099	0101											
C	0006	0009	0098	0099	0102	0103												
D	0006	0009	0091	0092	0095	0095	0099	0100	0102	0102								
E	0062	0144																
F	0006	0009																
G	0006	0009	0095	0099														
I	0012	0013	0034	0035	0035	0036	0039	0039	0040	0041	0041	0044	0045	0045	0046	0047	0047	0048	0049
	0049	0049	0049	0049	0107	0108	0108	0126	0128	0128	0142	0143	0143	0143					
P	0144																		
S	0006	0009	0014	0015	0016														
U	0115	0116																	
X	0006	0009	0056	0057	0057	0058	0058	0059	0060	0060	0061	0061	0061	0062	0062	0062	0063	0063	0063
	0064	0064	0072	0072	0073	0073	0074	0074	0075	0075	0075	0076	0076	0076	0077	0077	0077	0078	0078
	0078	0079	0081	0083	0084	0085	0085	0085	0086	0086	0086	0087	0087	0087	0088	0088	0089	0089	0090
	0090	0091	0091	0092	0092	0093	0093	0093	0094	0094	0094	0095	0095	0095	0095	0095	0095	0095	0096
	0096	0096	0097	0097	0097	0097	0098	0098	0098	0098	0099	0099	0099	0099	0100	0100	0101	0102	0102	0102
	0103	0103																	
AG	0007	0009	0020	0021	0022	0023	0024	0025	0026	0027	0028	0029	0030	0031	0049				
A1	0006	0009	0061	0062	0063	0066	0067	0068	0069	0070	0071	0110	0111	0112	0113	0115	0115	0117	0119
	0121																		
A2	0009																		
A3	0009																		
DT	0002	0023	0024	0025	0032	0033	0035	0036	0037	0039	0042	0043	0045						
D1	0007	0009	0032	0033	0035	0049													
D2	0007	0009	0036	0037	0039	0041	0041	0049											
D3	0007	0009	0042	0043	0045	0047	0047	0049											
EL	0006	0009	0061	0061	0061	0062	0062	0062	0063	0063	0063	0064	0064	0064	0065				
EN	0144																		
ET	0119	0122	0129																
GP	0006	0009	0144																
GI	0009	0070	0084	0084	0102														
H1	0009	0071	0103																
RA	0117	0118	0119																
RX	0006	0009	0144																
S1	0014	0017																	
S2	0015	0018																	
S3	0016	0019																	
TH	0110	0122	0129																
TU	0008	0009																	
UG	0009	0102	0105																
UH	0009	0103	0106																
UL	0009	0101	0104																
VX	0006	0009	0144																
AG4	0026	0029																	
AG5	0027	0030																	
AG6	0028	0031																	
AL1	0009	0069	0072	0096	0101														
ARG	0008	0009																	
A11	0006	0009	0046	0050	0051	0052	0053	0054	0055	0056	0056	0057	0059	0061	0062	0063	0064	0066	0067
	0068																		
CJ3	0009	0122	0129																
CJ4	0009	0122	0129																
CMU	0009	0120	0122	0129															

****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS
DJ0	0009
DS1	0017 0025
DS2	0016 0024
DS3	0019 0023
DIE	0009 0064 0065 0067 0099
DII	0009 0065 0066 0100
ECC	0111 0122 0129
END	0009
ERR	0009 0072 0144
FAN	0002 0144
NIT	0002 0072 0144
REM	0009 0113 0130 0131 0132 0133
X12	0079 0080
X13	0081 0082
ALLH	0122
AIDH	0007 0009 0032 0033 0035 0036 0037 0039 0042 0043 0045
ARGU	0008 0009
A110	0006 0009 0020 0021 0022 0023 0024 0025 0072 0073 0078 0093 0096 0097 0097 0098 0099 0100
A114	0050 0055
A115	0051 0054
A116	0052 0053
CARG	0121 0122 0129
CARL	0120 0121 0122 0129 0130 0131 0132 0133
CJ2S	0009 0122 0129
CONV	0009 0035 0039 0045 0143
DAJ3	0009 0131 0137
DAJ4	0009 0132 0137
DCOS	0059 0060 0064 0090 0093 0093 0110 0117 0119
DLJ3	0009 0122 0129 0131
DLJ4	0009 0122 0129 0132
DSIN	0058 0064 0064 0088 0089 0097
DSUP	0006 0009 0013 0140 0141 0143
DTAN	0115
DUM1	0005 0009
DX12	0080 0083
DX13	0082 0083
ECA1	0009 0072 0114 0115 0117
ELRV	0144
GDIF	0002 0072 0144
NARG	0009
NKOZ	0009
NMAX	0002 0072 0144
NSEC	0009 0109
RALV	0002 0144
XKEP	0072
ALLOT	0029 0030 0031 0053 0054 0055 0069 0070 0071 0104 0105 0106
ATANQ	0083
BR**2	0002
CCOSP	0008 0009
DADLH	0008 0122 0128
DAJ2S	0009 0130 0137
DASUM	0009 0011 0133 0134
DATAN	0116
DLJ2S	0009 0122 0125 0130

**** FORTRAN CROSS REFERENCE LISTING ****

SYMBOL	INTERNAL STATEMENT NUMBERS				
DLSUM	0009	0122	0129	0133	
DSQRT	0115	0119	0120	0121	
NKUZD	0009				
NLONG	0009				
NSECD	0009	0126	0136		
NSUPP	0009	0138			
SCLEF	0008	0009			
SUPP1	0139				
APRIML	0113	0118	0120	0122	0129
ARGMCT	0008	0009			
ASHORT	0008	0009	0108		
DTIMES	0009				
EPRIME	0114				
FPRIME	0116	0119	0122	0129	
GPRIME	0117	0122	0129		
KCOUNT	0009	0125	0135		
NBRSHI	0009				
NSHORT	0009				
NSUPPD	0009				
RPRIML	0118	0122	0129		

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
9	0053	
10	0054	
11	0055	
15	0056	
16	0057	
17	0058	
18	0059	
19	0060	
20	0061	
21	0062	
22	0063	
23	0064	
24	0065	
25	0066	
26	0067	
28	0069	
29	0070	
30	0071	
31	0072	
33	0073	
34	0074	
35	0075	
36	0076	
37	0077	
38	0078	
40	0084	
41	0085	
42	0086	
43	0087	
44	0088	
45	0089	
46	0090	
47	0091	
48	0092	
49	0093	
50	0094	
51	0095	
52	0096	
53	0097	
54	0098	
55	0099	
56	0100	
57	0101	
58	0102	
59	0103	
60	0104	
61	0105	
62	0106	
63	0144	0138
621	0139	0138 0138
629	0143	0142
700	0013	0012
1000	0004	
1002	0035	0034

*****F O R T R A N C R O S S R E F E R E N C E L I S T I N G*****

LABEL	DEFINED	REFERENCES			
1003	0039	0038			
1004	0045	0044			
1005	0049	0048			
1013	0041	0040			
1014	0047	0046			
1828	0123	0128	0129		
1850	0010	0137			
1860	0124	0127			
2000	0130	0125	0125	0126	
2001	0127	0126	0126		
2002	0126	0125			
6200	0110	0109	0109		
6210	0138	0109	0135	0135	0136
6220	0108	0107			
8299	0136	0135			
8300	0137	0136	0136		

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          COMPILER OPTIONS -  NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
               CSUBROUTINE BRWR4                                                                    00067600
   ISN 0002          SUBROUTINE BRWR4  (/DT/,      E,FAN,RADV,GDIF,NMAX,NIT)                       00067610
   ISN 0003          IMPLICIT REAL*8(A-H,O-Z,$)                                                    00067620
                  C                                                                                00067630
                  C     VERSION OF 01/31/64                                                        00067640
                  C           FORTRAN SUBROUTINE                                                   00067650
                  C     THE SHORT PERIOD TERMS COMPUTED IN THIS ROUTINE ARE COMPUTED WITH          00067660
                  C     E' AND I' INSTEAD OF WITH E" AND I" AS SPECIFIED BY BROUWER.               00067670
                  C     AJ,NOV. 1959.                                                              00067680
                  C     OTHERWISE THE ROUTINE IS THE SAME AS BRWR2.                                00067690
                  C                                                                                00067700
                  C     PURPOSE                                                                    00067710
                  C           COMPUTES THE VALUES OF THE OSCULATING ELEMENTS AND THE               00067720
                  C           POSITION-VELOCITY VECTOR FOR ANY TIME.                               00067730
                  C           THE SHORT-PERIOD PERTURBATIONS ARE COMPUTED WITH E' AND I'.           00067740
                  C                                                                                00067750
                  C     DUM1 IS A DUMMY VARIABLE INSERTED AS FIRST VARIABLE IN COMMON IN           00067760
                  C     BRWR1,BRWR2,AND BRWR4 TO PERMIT SHIFTING OF VARIABLES IN COMMON            00067770
                  C     AREA IF DESIRED. THE DIMENSION OF DUM1 MAY BE CHANGED BUT SHOULD           00067780
                  C     BE THE SAME IN SUBROUTINES BRWR1,BRWR2,AND BRWR4,AND THE CALLING           00067790
                  C     PROGRAM.                                                                   00067800
                  C     CALLING SEQUENCE                                                           00067810
                  C                 CALL BRWR4(DT,E,FAN,RADV,GDIF,NMAX,NIT)                        00067820
                  C                                                                                00067830
                  C     INPUT                                                                      00067840
                  C           DT    = TIME ELAPSED FROM EPOCH OF MEAN ELEMENTS - SECONDS           00067850
                  C           NMAX  = MAXIMUM NUMBER OF ITERATIONS ALLOWED                         00067860
                  C                   SEE SUBROUTINE BRWR1 FOR INPUT VIA COMMON                    00067870
                  C                                                                                00067880
                  C     OUTPUT                                                                     00067890
                  C           E     = ECCENTRIC ANOMALY                          RADIANS           00067900
                  C           FAN   = TRUE ANOMALY                               RADIANS           00067910
                  C           RADV  = RADIUS VECTOR                              KILOMETERS        00067920
                  C           GDIF  = LAST CORRECTION (E2-E1)/E2                                   00067930
                  C                   IN SOLVING KEPLER'S EQUATION.                                00067940
                  C           NIT   = SERIAL NUMBER OF CURRENT ITERATION IN SOLVING                00067950
                  C                   KEPLER'S EQUATION                                            00067960
                  C                                                                                00067970
   ISN 0004        1000 CONTINUE                                                                   00067980
                  C     OUTPUT VIA COMMON                                                          00067990
                  C           OSCULATING ORBITAL ELEMENTS AT TIME T = EPOCH TIME + DT             00068000
                  C                                                                                00068010
                  C           A(1) = SEMI-MAJOR AXIS                    - KILOMETERS               00068020
                  C           A(2) = ECCENTRICITY                       - DIMENSIONLESS            00068030
                  C           A(3) = INCLINATION                        - RADIANS                  00068040
                  C           A(4) = RIGHT ASCENSION OF ASCENDING NODE  - RADIANS                  00068050
                  C           A(5) = ARGUMENT OF PERIGEE                - RADIANS                  00068060
                  C           A(6) = MEAN ANOMALY                       - RADIANS                  00068070
                  C                                                                                00068080
                  C     REQUIRED SUBPROGRAMS                                                       00068090
                  C           07/22/63  ALLOT                                                      00068100
                  C                     ADLH                                                       00068110
                  C           03/03/64  ATANQ                                                      00068120
                  C           03/02/64  ELRV                                                       00068130
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                C                       SUPP1                                                   00068140
                C             09/12/63  *KEP                                                    00068150
                C                                                                               00068160
                C                                                                               00068170
                C     TIMING                                                                    00068180
                C             NO ESTIMATE AVAILABLE                                             00068190
                C                                                                               00068200
                C                                                                               00068210
                C                                                                               00068220
                C***** START PROGRAM ************************************************************00068230
                C                                                                               00068240
ISN 0005              DIMENSION DUM1(10C)                                                       00068250
ISN 0006              DIMENSION A110(6),GP(5),A11(6),A1(6),A(6),RX(3),VX(3),EL(13),F(9),00068260
                     1    B(9),C(10),D(23),G(13),X(28),S(3)                                   00068270
ISN 0007              DIMENSION AG(6),D1(6),D2(6),D3(6)  ,AIDH(24)                              00068280
ISN 0008              DIMENSION T0(99),ARG0(99),ARGMOT(99),ARG(99),CCOEF(99,6),                 00068290
                     1SCOEF(99,6),DSUP(6),ASHORT(6),DADLH(19)                                   00068300
                C                                                                               00068310
ISN 0009              COMMON DUM1,A110,GP,ERR,A11,A1,A,RX,VX,EN0,ECA1,D1E,D1I,AL1,UL,           00068320
                     1  G1,UG,H1,UH,S,EL,A2,A3,B,C,D,G,X,F,                                    00068330
                     1CCNV,AIDH,AG,D1,D2,D3 ,CMU,T0,DJ0,DTIMES,ARG0,ARGMOT,ARG,CCOEF,          00068340
                     3SCOEF,DSUP,CJ2S,CJ3,CJ4,DLJ2S,DLJ3,DLJ4,DLSUM,DAJ2S,DAJ3,DAJ4,           00068350
                     4DASUM,REM , ASHORT                                                        00068360
                     5            NBR#R1,NLONG,NSHORT,NSEC,NSECD,NSUPP,NSUPPD,NARG,KCOUNT00068370
                     6,NKOZ,NKOZD                                                               00068380
ISN 0010       1850 FORMAT(//13X,106HCONTRIBUTION OF J2 SQUARE, J3 , J4 , AND G# - G' 00068390
                     1TO SECOND ORDER SHORT PERIOD TERMS IN A AND TERM DA**2/4A/                00068400
                     2 59X,13HIN MEGAMETERS/                                                    00068410
                     314X,5(F18.10,3X)///)                                                      00068420
                C                                                                               00068430
ISN 0011              FJ2=2.D 00*GP(2)/(REM*1.D 03)**2                                          00068440
ISN 0012              CASUM=0.D 00                                                              00068450
ISN 0013              DO 700 I=1,6                                                              00068460
ISN 0014        700   DSUP(I)=0.D C0                                                            00068470
                C     COMPUTE SECULAR TERMS                                                     00068480
                C                                                                               00068490
ISN 0015              S1 = S(1)                                                                 00068500
ISN 0016              S2 = S(2)                                                                 00068510
ISN 0017              S3 = S(3)                                                                 00068520
ISN 0018              DS1 = S1                                                                  00068530
ISN 0019              DS2 = S2                                                                  00068540
ISN 0020              DS3=S3                                                                    00068550
ISN 0021              AG(1)=A110(1)                                                             00068560
ISN 0022              AG(2)=A110(2)                                                             00068570
ISN 0023              AG(3)=A110(3)                                                             00068580
ISN 0024              AG(4)=A110(4) +DS3*DT                                                     00068590
ISN 0025              AG(5)=A110(5) +DS2*DT                                                     00068600
ISN 0026              AG(6)=A110(6) +DS1*DT                                                     00068610
ISN 0027              AG4=AG(4)                                                                 00068620
ISN 0028              AG5=AG(5)                                                                 00068630
ISN 0029              AG6=AG(6)                                                                 00068640
ISN 0030              AG(4)=ALLOT (AG4)                                                         00068650
ISN 0031              AG(5)=ALLOT (AG5)                                                         00068660
ISN 0032              AG(6)=ALLOT (AG6)                                                         00068670
ISN 0033              D1(1)=DT*AIDH(7)*1.D 00/3.6D 00                                           00068680
ISN 0034              D1(2)=DT*AIDH(8)/3.6D 03                                                  00068690
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ISN 0035            DO 1002 I=3,6                                                          00068700
ISN 0036         1002 D1(I)=DT*AIDH(I+6)/(CONV*3.6D 03)                                    00068710
ISN 0037            D2(1)=DT**2*AIDH(13)/1.296D 04                                         00068720
ISN 0038            D2(2)=DT**2*AIDH(14)/1.296D 07                                         00068730
ISN 0039            DO 1003 I=3,6                                                          00068740
ISN 0040         1003 D2(I)=DT**2*AIDH(I+12)/(CONV*1.296D 07)                              00068750
                 C      TO ALLOW FOR THE FACT THAT AIDH(I),I=13,18 ARE PER (100HRS)SQUARED 00068760
ISN 0041            DO 1013 I=1,6                                                          00068770
ISN 0042         1013 D2(I)=1.D-04*D2(I)                                                   00068780
ISN 0043            D3(1)=DT**3*AIDH(19)/4.6656D 07                                        00068790
ISN 0044            D3(2)=DT**3*AIDH(20)/4.6656D 10                                        00068800
ISN 0045            DO 1004 I=3,6                                                          00068810
ISN 0046         1004 D3(I)=DT**3*AIDH(I+18)/(CONV*4.6656D 10)                             00068820
                 C      TO ALLOW FOR THE FACT THAT AIDH(I),I=19,24 ARE PER (100HRS)CUBED    00068830
ISN 0047            DO 1014 I=1,6                                                          00068840
ISN 0048         1014 D3(I)=1.D-06*D3(I)                                                   00068850
ISN 0049            DO 1005 I=1,6                                                          00068860
ISN 0050         1005 A11(I)=AG(I)+D1(I)+D2(I)+D3(I)                                       00068870
ISN 0051            A114=A11(4)                                                            00068880
ISN 0052            A115=A11(5)                                                            00068890
ISN 0053            A116=A11(6)                                                            00068900
ISN 0054              9 A11(6) = ALLOT (A116)                                              00068910
ISN 0055             10 A11(5) = ALLOT (A115)                                              00068920
ISN 0056             11 A11(4) = ALLOT (A114)                                              00068930
                 C      COMPUTE LONG PERIOD TERMS                                       00068940
                 C                                                                      00068950
ISN 0057             15 X(1)=A11(5)+A11(5)                                              00068960
ISN 0058             16 X(2)=X(1)+A11(5)                                                00068970
ISN 0059             17 X(3)=DSIN(X(1))                                                 00068980
ISN 0060             18 X(4)=DCOS(A11(5))                                               00068990
ISN 0061             19 X(5)=DCOS(X(2))                                                 00069000
ISN 0062             20 A1(6)=A11(6)+EL(1)*X(3)+EL(2)*X(4)+EL(3)*X(5)                   00069010
ISN 0063             21 A1(5)=A11(5)+EL(4)*X(3)+EL(5)*X(4)+EL(6)*X(5)                   00069020
ISN 0064             22 A1(4)=A11(4)+EL(7)*X(3)+EL(8)*X(4)+EL(9)*X(5)                   00069030
ISN 0065             23 D1E=EL(10)*DCOS(X(1))+EL(11)*DSIN(A11(5))+EL(12)*DSIN(X(2))     00069040
ISN 0066             24 D1I=EL(13)*D1E                                                  00069050
ISN 0067             25 A1(3)=A11(3)+D1I                                                00069060
ISN 0068             26 A1(2)=A11(2)+D1E                                                00069070
ISN 0069                A1(1)=A11(1)                                                    00069080
ISN 0070             28 AL1=ALLOT(A1(6))                                                00069090
ISN 0071             29 G1 =ALLOT(A1(5))                                                00069100
ISN 0072             30 H1 =ALLOT(A1(4))                                                00069110
                 C      TO WRITE LONG PERIOD TERMS                                      00069120
                 C                                                                      00069130
                 C      COMPUTE SHORT PERIOD TERMS                                      00069140
                 C                                                                      00069150
ISN 0073            F2=A1(2)**2                                                         00069160
ISN 0074            B1=1.D 00-F2                                                        00069170
ISN 0075            B2=DSQRT(B1)                                                        00069180
ISN 0076            B3=1.D 00+B2                                                        00069190
ISN 0077            B8=1.D 00/B3                                                        00069200
ISN 0078            B9=1.D 00/(B1*B1)                                                   00069210
ISN 0079            C1=GP(2)/A1(1)**2                                                   00069220
ISN 0080            C2=1.5D 00*C1*B9                                                    00069230
ISN 0081            C9=C2/6.D 00                                                        00069240
ISN 0082            Q=DCOS(A1(3))                                                       00069250
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ISN 0083           C10=C9*2.D 00*Q                                                  00069260
ISN 0084           Q=Q*Q                                                            00069270
ISN 0085           D7=5.D 00*Q-1.D 00                                               00069280
ISN 0086           D5=1.D 00-Q                                                      00069290
ISN 0087           D6=3.D 00*Q-1.D 00                                               00069300
ISN 0088           D19=3.D 00*D5                                                    00069310
ISN 0089           D20=D6+D6                                                        00069320
ISN 0090           D21=2.D 00-D7                                                    00069330
ISN 0091           D22=C10*DSQRT(D5)                                                00069340
ISN 0092           D23=4.D 00*C9*D5                                                 00069350
ISN 0093           G9=A1(2)*DSIN(A1(3))                                             00069360
ISN 0094           G11=B1/A1(2)                                                     00069370
ISN 0095           G12=.5D 00*G11                                                   00069380
ISN 0096           G13=G11*C9                                                       00069390
ISN 0097        31 ECA1=XKEP(AL1,A1(2)  ,X(6),X(7),ERR,GDIF,NMAX,NIT)              00069400
ISN 0098        33 X(8)=1.D0-A1(2)  *X(7)                                          00069410
ISN 0099        34 X(9)=1.D0/X(8)                                                  00069420
ISN 0100        35 X(10)=X(9)*X(9)                                                 00069430
ISN 0101        36 X(11)=X(9)*X(10)                                                00069440
ISN 0102        37 X(12)=X(6)*X(9)*B2                                              00069450
ISN 0103        38 X(13)=X(9)*(X(7)-A1(2)  )                                       00069460
                   X12 = X(12)                                                     00069470
ISN 0104           DX12 = X12                                                      00069480
ISN 0105           X13 = X(13)                                                     00069490
ISN 0106           DX13 = X13                                                      00069500
ISN 0107           X(14) = ATANQ(DX12,DX13)                                        00069510
ISN 0108        40 X(15)=G1+G1                                                     00069520
ISN 0109        41 X(16)=X(15)+X(14)                                               00069530
ISN 0110        42 X(17)=X(16)+X(14)                                               00069540
ISN 0111        43 X(18)=X(17)+X(14)                                               00069550
ISN 0112        44 X(19)=DSIN(X(16))                                               00069560
ISN 0113        45 X(20)=DSIN(X(18))                                               00069570
ISN 0114        46 X(21)=DCOS(X(17))                                               00069580
ISN 0115        47 X(22)=D6  *(X(11)-B8  )                                         00069590
ISN 0116        48 X(23)=D19  *X(21)                                               00069600
ISN 0117        49 X(24)=A1(2)  *(3.D0*DCOS(X(16))+DCOS(X(18)))                    00069610
ISN 0118        50 X(25)=X(9)+B1  *X(10)                                           00069620
ISN 0119        51 X(26)=G13  *(D20  *X(12)*(X(25)+1.D0)+D19  *((1.D0-X(25))*X(19)+00069630
                  1    (X(25)+.33333333D0)*X(20)))                               00069640
ISN 0120        52 X(27)=6.D0*(X(14)-AL1+A1(2)  *X(12))                            00069650
ISN 0121        53 X(28)=3.D0*(DSIN(X(17))+A1(2)  *X(19))+A1(2)  *X(20)            00069660
                C                                                                  00069670
                C     COMPUTE OSCULATING ELEMENTS                                  00069680
                C                                                                  00069690
ISN 0122        54 A(1)=A110(1)*(1.DC+C1  *(X(22)+X(11)*X(23)))                    00069700
ISN 0123        55 A(2)= A110(2)+D1E+G12  *(C1  *(X(22)+X(23)*(X(11)-B9  ))-D23  *00069710
                  1X(24))                                                          00069720
ISN 0124        56 A(3)=A110(3)+D1I+D22  *(3.D0*X(21)+X(24))                       00069730
ISN 0125        57 UL= AL1-B2  *X(26)                                              00069740
ISN 0126        58 UG= G1+X(26)+C9  *(D7  *X(27)+D21  *X(28))                      00069750
ISN 0127        59 UH= H1-C10  *(X(27)-X(28))                                      00069760
ISN 0128        60 A(6)=ALLOT(UL)                                                  00069770
ISN 0129        61 A(5)=ALLOT(UG)                                                  00069780
ISN 0130        62 A(4)=ALLOT(UH)                                                  00069790
ISN 0131           DO 6220 I=1,6                                                   00069800
ISN 0132      6220 ASHORT(I)=A(I)                                                  00069810
ISN 0133
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ISN 0134            IF(NSEC)6200,6210,6200                                          00069820
ISN 0135       6200 TH=DCOS(A1(3))                                                  00069830
ISN 0136            ECC=A1(2)                                                       00069840
ISN 0137            GPRIME=A1(5)                                                    00069850
ISN 0138            APRIME=A1(1)*1.D-03/REM                                         00069860
ISN 0139            EPRIME=ECA1                                                     00069870
ISN 0140            U=DSQRT((1.D 00+A1(2))/(1.D 00-A1(2)))*DTAN(ECA1/2.D 00)        00069880
ISN 0141            FPRIME=2.D 00*DATAN(U)                                          00069890
ISN 0142            RA=1.D 00-A1(2)*DCOS(ECA1)                                      00069900
ISN 0143            RPRIME=RA*APRIME                                                00069910
ISN 0144            ET=DSQRT(RA*(1.D 00+A1(2)*DCOS(FPRIME)))                        00069920
ISN 0145            CAPL=DSQRT(CMU*APRIME)                                          00069930
ISN 0146            CAPG=CAPL*DSQRT(1.D 00-A1(2)**2)                                00069940
ISN 0147            CALL ADLH(DLJ2S,DLJ3,DLJ4,DLSUM,                                00069950
                   1          TH,ECC,GPRIME,APRIME,RPRIME,ET,FPRIME,CAPG,CAPL,CMU,  00069960
                   2CJ2S,CJ3,CJ4,DADLH)                                             00069970
ISN 0148            DLPRL=(1.1250 00/CAPG**7)*(FJ2**2)*RA**(-3)                     00069980
ISN 0149            DLPRL=DLPRL*32**3                                               00069990
ISN 0150            DLPRL=DLPRL*(1.D 00-5.D 00*TH**2)*(1.D 00-TH**2)                00070000
ISN 0151            EQC=FPRIME-AL1                                                  00070010
ISN 0152       3000 IF(EQC-180.D 00/CONV)3002,3001,3001                             00070020
ISN 0153       3001 EQC=EQC-360.D 00/CONV                                           00070030
ISN 0154            GO TO 3000                                                      00070040
ISN 0155       3002 IF(EQC+180.D 00/CONV)3003,3004,3004                             00070050
ISN 0156       3003 EQC=EQC+360.D 00/CONV                                           00070060
ISN 0157            GO TO 3002                                                      00070070
ISN 0158       3004 DLPRL=DLPRL*EQC                                                 00070080
ISN 0159            STERM=DSIN(2.D 00*(FPRIME+G1))                                  00070090
ISN 0160            DLPRL=DLPRL*STERM                                               00070100
ISN 0161            DLSUM=DLSUM+DLPRL                                               00070110
ISN 0162       1828 FORMAT(6(1X,D21.14))                                            00070120
ISN 0163       1860 FORMAT(  1X,4HADLH)                                             00070130
ISN 0164            IF(KCOUNT)2000,2002,2000                                        00070140
ISN 0165       2002 IF(NSECD)2001,2000,2001                                         00070150
ISN 0166       2001 WRITE(6,1860)                                                   00070160
ISN 0167            WRITE(6,1828)(DADLH(I),I=1,19)                                  00070170
ISN 0168            WRITE(6,1828)TH,ECC,GPRIME,APRIME,RPRIME,ET,EPRIME,RA,U,AL1,G1, 00070180
                   1EQC,FPRIME,CAPG,CAPL,CMU,CJ2S,CJ3,CJ4                           00070190
ISN 0169            WRITE(6,1828)DLJ2S,DLJ3,DLJ4,DLPRL,DLSUM                        00070200
ISN 0170       2000 DAJ2S=2.D 00*CAPL*REM*DLJ2S                                     00070210
ISN 0171            DAJ3 =2.D 00*CAPL*REM*DLJ3                                      00070220
ISN 0172            DAJ4 =2.D 00*CAPL*REM*DLJ4                                      00070230
ISN 0173            DAPRL=2.D 00*CAPL*REM*DLPRL                                     00070240
ISN 0174            DASUM=2.D 00*CAPL*REM*DLSUM                                     00070250
ISN 0175            DSQA=1.D-03*(A(1)-A110(1))**2/(4.D 00*A110(1))                  00070260
ISN 0176            DASUM=DASUM+DSQA                                                00070270
ISN 0177            A(1)=A(1)+DASUM*1.D 03                                          00070280
ISN 0178            IF(KCOUNT)6210,8299,6210                                        00070290
ISN 0179       8299 IF(NSECD)8300,6210,8300                                         00070300
ISN 0180       8300 WRITE(6,1850)DAJ2S,DAJ3,DAJ4,DAPRL,DSQA                         00070310
ISN 0181       6210 IF(NSUPP)621,63,621                                             00070320
ISN 0182        621 CALL SUPP1                                                      00070330
ISN 0183            A(1)=A(1)+DSUP(1)*1.D 03                                        00070340
ISN 0184            A(2)=A(2)+DSUP(2)                                               00070350
ISN 0185            DO 629 I=3,6                                                    00070360
ISN 0186        629 A(I)=A(I)+DSUP(I)/CONV                                          00070370
```

```
                C                                                                   00070380
                C     COMPUTE POSITION AND VELOCITY COMPONENTS                      00070390
                C                                                                   00070400
ISN 0187           63 CALL ELRV (RX,VX,E,FAN,RADV,A,P,EN,GP(1),ERR,GDIF,NMAX,NIT)   00070410
ISN 0188              RETURN                                                        00070420
ISN 0189              END                                                           00070430
```

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS																		
A	0006	0009	0123	0124	0125	0129	0130	0131	0133	0175	0177	0177	0183	0183	0184	0184	0186	0186	0187
B	0006	0009																	
C	0006	0009																	
D	0006	0009																	
E	0002	0187																	
F	0006	0009																	
G	0006	0009																	
I	0013	0014	0035	0036	0036	0039	0040	0040	0041	0042	0042	0045	0046	0046	0047	0048	0048	0049	0050
	0050	0050	0050	0050	0132	0133	0133	0167	0167	0167	0185	0186	0186	0186					
P	0187																		
Q	0082	0083	0084	0084	0084	0085	0086	0087											
S	0006	0009	0015	0016	0017														
U	0140	0141	0168																
X	0006	0009	0057	0058	0058	0059	0059	0060	0061	0061	0062	0062	0062	0063	0063	0063	0064	0064	0064
	0065	0065	0097	0097	0098	0098	0099	0099	0100	0100	0100	0101	0101	0101	0102	0102	0102	0103	0103
	0103	0104	0106	0108	0109	0110	0110	0110	0111	0111	0111	0112	0112	0112	0113	0113	0114	0114	0115
	0115	0116	0116	0117	0117	0118	0118	0118	0119	0119	0119	0120	0120	0120	0120	0120	0120	0120	0121
	0121	0121	0122	0122	0122	0122	0123	0123	0123	0124	0124	0124	0124	0125	0125	0126	0127	0127	0127
	0128	0128																	
AG	0007	0009	0021	0022	0023	0024	0025	0026	0027	0028	0029	0030	0031	0032	0050				
A1	0006	0009	0062	0063	0064	0067	0068	0069	0070	0071	0072	0073	0079	0082	0093	0093	0094	0097	0098
	0103	0118	0121	0122	0122	0135	0136	0137	0138	0140	0140	0142	0144	0146					
A2	0009																		
A3	0009																		
B1	0074	0075	0076	0078	0078	0094	0119												
B2	0075	0076	0102	0126	0149														
B3	0076	0077																	
B8	0077	0116																	
B9	0078	0080	0124																
C1	0079	0080	0123	0124															
C2	0080	0081																	
C9	0081	0083	0092	0096	0127														
DT	0002	0024	0025	0026	0033	0034	0036	0037	0038	0040	0043	0044	0046						
D1	0007	0009	0033	0034	0036	0050													
D2	0007	0009	0037	0038	0040	0042	0042	0050											
D3	0007	0009	0043	0044	0046	0048	0048	0050											
D5	0086	0088	0091	0092															
D6	0087	0089	0089	0116															
D7	0085	0090	0127																
EL	0006	0009	0062	0062	0062	0063	0063	0063	0064	0064	0064	0065	0065	0065	0066				
EN	0187																		
ET	0144	0147	0168																
F2	0073	0074																	
GP	0006	0009	0011	0079	0187														
G1	0009	0071	0109	0109	0127	0159	0168												
G9	0093																		
H1	0009	0072	0128																
RA	0142	0143	0144	0148	0168														
RX	0006	0009	0187																
S1	0015	0018																	
S2	0016	0019																	
S3	0017	0020																	
TH	0135	0147	0150	0150	0168														
TO	0008	0009																	

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS
UG	0009 0127 0130
UH	0009 0128 0131
UL	0009 0126 0129
VX	0006 0009 0187
AG4	0027 0030
AG5	0028 0031
AG6	0029 0032
AL1	0009 0070 0097 0121 0126 0151 0168
ARG	0008 0009
A11	0006 0009 0050 0051 0052 0053 0054 0055 0056 0057 0057 0058 0060 0062 0063 0064 0065 0067 0068 0069
CJ3	0009 0147 0168
CJ4	0009 0147 0168
CMU	0009 0145 0147 0168
C10	0083 0091 0128
DJ0	0009
DS1	0018 0026
DS2	0019 0025
DS3	0020 0024
D1E	0009 0065 0066 0068 0124
D11	0009 0066 0067 0125
D19	0088 0117 0120
D20	0089 0120
D21	0090 0127
D22	0091 0125
D23	0092 0124
ECC	0136 0147 0168
END	0009
EQC	0151 0152 0153 0153 0155 0156 0156 0158 0168
ERR	0009 0097 0187
FAN	0002 0187
FJ2	0011 0148
G11	0094 0095 0096
G12	0095 0124
G13	0096 0120
NIT	0002 0097 0187
REM	0009 0011 0138 0170 0171 0172 0173 0174
X12	0104 0105
X13	0106 0107
ADLH	0147
AIDH	0007 0009 0033 0034 0036 0037 0038 0040 0043 0044 0046
ARGO	0008 0009
A110	0006 0009 0021 0022 0023 0024 0025 0026 0123 0124 0125 0175 0175
A114	0051 0056
A115	0052 0055
A116	0053 0054
CAFG	0146 0147 0148 0168
CAPL	0145 0146 0147 0168 0170 0171 0172 0173 0174
CJ2S	0009 0147 0168
CONV	0009 0036 0040 0046 0152 0153 0155 0156 0186
DAJ3	0009 0171 0180
DAJ4	0009 0172 0180
DCOS	0060 0061 0065 0082 0115 0118 0118 0135 0142 0144
DLJ3	0009 0147 0169 0171

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS											
DLJ4	0009	0147	0169	0172								
DSIN	0059	0065	0065	0093	0113	0114	0122	0159				
DSQA	0175	0176	0180									
DSUP	0008	0009	0014	0183	0184	0186						
DTAN	0140											
DUM1	0005	0009										
DX12	0105	0108										
DX13	0107	0108										
ECA1	0009	0097	0139	0140	0142							
ELRV	0187											
GDIF	0002	0097	0187									
NARG	0009											
NKOZ	0009											
NMAX	0002	0097	0187									
NSEC	0009	0134										
RADV	0002	0187										
XKEP	0097											
ALLOT	0030	0031	0032	0054	0055	0056	0070	0071	0072	0129	0130	0131
ATANQ	0108											
ERWR4	0002											
COCEF	0008	0009										
DADLH	0008	0147	0167									
DAJ2S	0009	0170	0180									
DAPRL	0173	0180										
DASUM	0009	0012	0174	0176	0176	0177						
DATAN	0141											
DLJ2S	0009	0147	0169	0170								
DLPRL	0148	0149	0149	0150	0150	0158	0158	0160	0160	0161	0169	0173
DLSUM	0009	0147	0161	0161	0169	0174						
DSQRT	0075	0091	0140	0144	0145	0146						
NKOZD	0009											
NLONG	0009											
NSECD	0009	0165	0179									
NSUPP	0009	0181										
SCOEF	0008	0009										
STERM	0159	0160										
SUPP1	0182											
APRIME	0138	0143	0145	0147	0168							
ARGMOT	0008	0009										
ASHORT	0008	0009	0133									
DTIMES	0009											
EPRIME	0139	0168										
FPRIME	0141	0144	0147	0151	0159	0168						
GPRIME	0137	0147	0168									
KCOUNT	0009	0164	0178									
NBRWR1	0009											
NSHORT	0009											
NSUPPD	0009											
RPRIME	0143	0147	0168									

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
9	0054	
10	0055	
11	0056	
15	0057	
16	0058	
17	0059	
18	0060	
19	0061	
20	0062	
21	0063	
22	0064	
23	0065	
24	0066	
25	0067	
26	0068	
28	0070	
29	0071	
30	0072	
31	0097	
33	0098	
34	0099	
35	0100	
36	0101	
37	0102	
38	0103	
40	0109	
41	0110	
42	0111	
43	0112	
44	0113	
45	0114	
46	0115	
47	0116	
48	0117	
49	0118	
50	0119	
51	0120	
52	0121	
53	0122	
54	0123	
55	0124	
56	0125	
57	0126	
58	0127	
59	0128	
60	0129	
61	0130	
62	0131	
63	0187	0181
621	0182	0181 0181
629	0186	0185
700	0014	0013
1000	0004	
1002	0036	0035

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES			
1003	0040	0039			
1004	0046	0045			
1005	0050	0049			
1013	0042	0041			
1014	0048	0047			
1828	0162	0167	0168	0169	
1850	0010	0180			
1860	0163	0166			
2000	0170	0164	0164	0165	
2001	0166	0165	0165		
2002	0165	0164			
3000	0152	0154			
3001	0153	0152	0152		
3002	0155	0152	0157		
3003	0156	0155			
3004	0158	0155	0155		
6200	0135	0134	0134		
6210	0181	0134	0178	0178	0179
6220	0133	0132			
8299	0179	0178			
8300	0180	0179	0179		

```
         COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
               SUBROUTINE DJUL                                                                  00086430
ISN 0002             REAL FUNCTION DJUL*8(NM,ND,NY)                                           00086440
ISN 0003             IMPLICIT REAL*8(A-H,O-Z,F)                                               00086450
                     C                                                                        00086460
                     C     VERSION OF 07/22/63                                                00086470
                     C           FORTRAN FUNCTION                                             00086480
                     C                                                                        00086490
                     C     PURPOSE                                                            00086500
                     C           COMPUTES JULIAN DATE AT 0 HOURS UNIVERSAL TIME (OR           00086510
                     C           0 HOURS EPHEMERIS TIME).                                     00086520
                     C                                                                        00086530
                     C     CALLING SEQUENCE                                                   00086540
                     C           NAME = DJUL(NM,ND,NY)                                        00086550
                     C                                                                        00086560
                     C     INPUT                                                              00086570
                     C           NM    = CALENDAR MONTH                                       00086580
                     C           ND    = CALENDAR DAY                                         00086590
                     C           NY    = CALENDAR YEAR                                        00086600
                     C                                                                        00086610
                     C     OUTPUT                                                             00086620
                     C           NAME = JULIAN DATE AT 0 HOURS UNIVERSAL TIME                 00086630
                     C                                                                        00086640
                     C     REFERENCE                                                          00086650
                     C           REFER TO MATHEMATICAL DESCRIPTION IN SUBPROGRAM WRITEUP      00086660
                     C                                                                        00086670
                     C     METHOD                                                             00086680
                     C           THE NUMBER OF DAYS WHICH HAVE ELAPSED FROM 12 HOURS          00086690
                     C           UNIVERSAL TIME JAN. 0, 1800 ARE COUNTED AND ADDED TO THE     00086700
                     C           JULIAN DATE OF 12 HOURS UNIVERSAL TIME OF JAN. 0, 1800.      00086710
                     C                                                                        00086720
                     C     RESTRICTIONS                                                       00086730
                     C           DATE RESTRICTED TO LIE BETWEEN JANUARY 1, 1801 AND DECEMBER00086740
                     C           31, 2000.                                                    00086750
                     C                                                                        00086760
                     C     ACCURACY                                                           00086770
                     C           EXACT BINARY REPRESENTATION WITHIN DATE LIMITATIONS.         00086780
ISN 0004           1 CONTINUE                                                                 00086790
                     C                                                                        00086800
                     C     REQUIRED SUBPROGRAMS                                               00086810
                     C           MAD                                                          00086820
                     C                                                                        00086830
                     C                                                                        00086840
                     C     TIMING                                                             00086850
                     C           NO ESTIMATE AVAILABLE                                        00086860
                     C                                                                        00086870
                     C                                                                        00086880
                     C                                                                        00086890
                     C                                                                        00086900
                     C***** START PROGRAM ***************************************************00086910
                     C                                                                        00086920
ISN 0005             DIMENSION RM(12)                                                         00086930
                     C                                                                        00086940
ISN 0006           5 RM(1)=0.0D0                                                              00086950
ISN 0007           6 RM(2)=31.0D0                                                             00086960
```

```
ISN 0008          7 RM(3)=28.0D0                                                00086970
ISN 0009          8 RM(4)=31.0D0                                                00086980
ISN 0010          9 RM(5)=30.0D0                                                00086990
ISN 0011         10 RM(6)=31.0D0                                                00087000
ISN 0012         11 RM(7)=30.0D0                                                00087010
ISN 0013         12 RM(8)=31.0D0                                                00087020
ISN 0014         13 RM(9)=31.0D0                                                00087030
ISN 0015         14 RM(10)=30.0D0                                               00087040
ISN 0016         15 RM(11)=31.0D0                                               00087050
ISN 0017         16 RM(12)=30.0D0                                               00087060
                 C                                                              00087070
ISN 0018         17 Y=NY-1800                                                   00087080
ISN 0019         18 YL=IDINT((Y-1.0D0)/4.0D0)                                   00087090
ISN 0020         19 YC=IDINT((Y+99.0D0)/100.0D0)-1                              00087100
ISN 0021         20 RY=Y-YL                                                     00087110
ISN 0022         21 DJUL=RY*365.0D0+YL*366.0D0-YC+2378495.5D0                   00087120
ISN 0023         22 TD=ND                                                       00087130
ISN 0024         23 DO 24 N=1,NM                                                00087140
ISN 0025         24 DJUL=DJUL+RM(N)                                             00087150
ISN 0026         25 IF (NM-2) 29,29,26                                          00087160
ISN 0027         26 IF (Y-100.0D0) 27,29,27                                     00087170
ISN 0028         27 IF ( MAD (NY,4)) 29,28,29                                   00087180
ISN 0029         28 DJUL=DJUL+1.0D0                                             00087190
ISN 0030         29 DJUL=DJUL+TD                                                00087200
ISN 0031            RETURN                                                      00087210
ISN 0032            END                                                         00087220
```

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS														
N	0024	0025													
Y	0016	0019	0020	0021	0027										
ND	0002	0023													
NM	0002	0024	0026												
NY	0002	0018	0028												
RM	0005	0006	0007	0008	0009	0010	0011	0012	0013	0014	0015	0016	0017	0025	
RY	0021	0022													
TD	0023	0030													
YC	0020	0022													
YL	0019	0021	0022												
MAD	0026														
DJUL	0002	0022	0025	0025	0029	0029	0030	0030							
IDINT	0019	0020													

FORTRAN CROSS REFERENCE LISTING

LABEL	DEFINED	REFERENCES
1	0004	
5	0006	
6	0007	
7	0008	
8	0009	
9	0010	
10	0011	
11	0012	
12	0013	
13	0014	
14	0015	
15	0016	
16	0017	
17	0018	
18	0019	
19	0020	
20	0021	
21	0022	
22	0023	
23	0024	
24	0025	0024
25	0026	
26	0027	0026
27	0028	0027 0027
28	0029	0026
29	0030	0026 0026 0027 0028 0028

```
          COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
               CSUBROUTINE DMAD                                                                    00087230
   ISN 0002            REAL FUNCTION DMAC*8(X,Y)                                                   00087240
   ISN 0003            IMPLICIT REAL*8(A-H,O-Z,$)                                                  00087250
   ISN 0004            IF(Y.EQ.0.0D0)GO TO 10                                                      00087260
   ISN 0006            K=X/Y                                                                       00087270
   ISN 0007            DMAC=X-K*Y                                                                  00087280
   ISN 0008            RETURN                                                                      00087290
   ISN 0009         10 DMAC=0.0D0                                                                  00087300
   ISN 0010            RETURN                                                                      00087310
   ISN 0011            END                                                                         00087320
```

*****F O R T R A N C R O S S R E F E R E N C E L I S T I N G*****

SYMBOL	INTERNAL STATEMENT NUMBERS			
K	0006	0007		
X	0002	0006	0007	
Y	0002	0004	0006	0007
DMAD	0002	0007	0009	

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
10	0009	0004

```
          COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
                SUBROUTINE ELRV                                                                          00089100
   ISN 0002             SUBROUTINE ELRV (X,VX,E,F,RADV,A,P,EN,GM,ERR,GDIF,NMAX,NIT)                     00089110
   ISN 0003             IMPLICIT REAL*8(A-H,O-Z,$)                                                      00089120
                C                                                                                        00089130
                C       NAME CHANGED 11/12/68 FROM ELRVZ TO ELRV                                         00089140
                C                                                                                        00089150
                C                                                                                        00089160
                C       VERSION OF 03/02/64                                                              00089170
                C             FORTRAN SUBROUTINE                                                         00089180
                C                                                                                        00089190
                C       PURPOSE                                                                          00089200
                C             CONVERTS OSCULATING ORBITAL ELEMENTS INTO GEOCENTRIC                       00089210
                C             EQUATORIAL INERTIAL RECTANGULAR COORDINATES OF POSITION                    00089220
                C             AND VELOCITY.                                                              00089230
                C                                                                                        00089240
                C       CALLING SEQUENCE                                                                 00089250
                C             CALL ELRV (X,VX,E,F,RADV,A,P,EN,GM,ERR,GDIF,NMAX,NIT)                      00089260
                C                                                                                        00089270
                C                                                                                        00089280
                C       INPUT                                                                            00089290
                C             A(1) = SEMI-MAJOR AXIS                                                     00089300
                C             A(2) = ECCENTRICITY                          - DIMENSIONLESS               00089310
                C             A(3) = INCLINATION                           - RADIANS                     00089320
                C             A(4) = RIGHT ASCENSION OF ASCENDING NODE     - RADIANS                     00089330
                C             A(5) = ARGUMENT OF PERIGEE                   - RADIANS                     00089340
                C             A(6) = MEAN ANOMALY                          - RADIANS                     00089350
                C                                                                                        00089360
                C             GM   = THE PRODUCT OF G, THE GAUSSIAN CONSTANT SQUARED,                    00089370
                C                    AND M, THE MASS OF THE EARTH                                        00089380
                C             ERR  = TRUNCATION FACTOR REQUIRED IN XKEPZ FUNCTION                        00089390
                C             NMAX  = MAXIMUM NUMBER OF ITERATIONS ALLOWED                               00089400
                C                     IN SOLVIMG KEPLER'S EQUATION                                       00089410
                C                     IN RADIANS                                                         00089420
                C                                                                                        00089430
                C             UNITS OF INPUT ARGUMENTS A(1) AND GM ARE ARBITRARY                         00089440
                C             BUT MUST BE MUTUALLY CONSISTENT.                                           00089450
                C             INPUT ARGUMENTS MUST BE AVAILABLE IN CALLING PROGRAM IN                    00089460
                C             DOUBLE PRECISION FORM.                                                     00089470
                C                                                                                        00089480
                C       OUTPUT                                                                           00089490
                C             X(1)                                                                       00089500
                C             X(2)   THE 3 RECTANGULAR COORDINATES OF POSITION                           00089510
                C             X(3)                                                                       00089520
                C                                                                                        00089530
                C             VX(1)                                                                      00089540
                C             VX(2)  THE 3 RECTANGULAR COMPONENTS OF VELOCITY                            00089550
                C             VX(3)                                                                      00089560
                C             E    = ECCENTRIC ANOMALY                                                   00089570
                C             F    = TRUE      ANOMALY                                                   00089580
                C             RADV = RADIUS VECTOR                                                       00089590
                C                                                                                        00089600
                C             P    = ANOMALISTIC PERIOD                                                  00089610
                C             EN   = MEAN ANGULAR MOTION                                                 00089620
                C             GDIF  = LAST CORRECTION (E2-E1)/E2                                         00089630
```

```
C                       IN SOLVING KEPLER'S EQUATION.                          00089640
C              NIT    = SERIAL NUMBER OF CURRENT ITERATION IN SOLVING          00089650
C                       KEPLER'S EQUATION                                      00089660
C                                                                              00089670
C              UNITS OF OUTPUT ARGUMENTS X, VX, P, AND EN WILL DEPEND          00089680
C              UPON THE UNITS EMPLOYED FOR A(1) AND GM.                        00089690
C              OUTPUT ARGUMENTS ARE RETURNED TO CALLING PROGRAM IN DOUBLE      00089700
C              FORM.                                                           00089710
ISN 0004     100 CONTINUE                                                      00089720
C                                                                              00089730
C     REFERENCE                                                                00089740
C              REFER TO MATHEMATICAL DESCRIPTION IN SUBPROGRAM WRITEUP         00089750
C                                                                              00089760
C     METHOD                                                                   00089770
C              REFER TO MATHEMATICAL DESCRIPTION IN SUBPROGRAM WRITEUP         00089780
C                                                                              00089790
C     RESTRICTIONS                                                             00089800
C              ECCENTRICITY MUST BE LESS THAN 1.0.                             00089810
C                                                                              00089820
C     ACCURACY                                                                 00089830
C              REFER TO ACCURACY TESTS IN SUBPROGRAM WRITEUP.                  00089840
C              INTERNAL ARITHMETIC IS PERFORMED IN DOUBLE PRECISION.           00089850
C                                                                              00089860
C     REQUIRED SUBPROGRAMS                                                     00089870
C                         ALLOT                                                00089880
C              09/12/63   XKEP                                                 00089890
C                                                                              00089900
C                                                                              00089910
C     TIMING                                                                   00089920
C              NO ESTIMATE AVAILABLE                                           00089930
C                                                                              00089940
C                                                                              00089950
C                                                                              00089960
C     PROGRAM MODIFICATIONS                                                    00089970
C                                                                              00089980
C***** START PROGRAM ***************************************************** 00089990
C                                                                              00090000
ISN 0005           DIMENSION X(3),VX(3),A(6)                                   00090010
C                                                                              00090020
ISN 0006           A1=A(1)                                                     00090030
ISN 0007           A2=A(2)                                                     00090040
ISN 0008           A3=A(3)                                                     00090050
ISN 0009           A4=A(4)                                                     00090060
ISN 0010           A5=A(5)                                                     00090070
ISN 0011           A6=A(6)                                                     00090080
ISN 0012         4 E=XKEP (A6,A2,SE,CE,ERR,GDIF,NMAX,NIT)                      00090090
ISN 0013           E=ALLOT (E)                                                 00090100
ISN 0014           F=(1.D 00+A2)/(1.D 00-A2)                                   00090110
ISN 0015           F=DSQRT(F)                                                  00090120
ISN 0016           F=F*DTAN(E*0.5D 00)                                         00090130
ISN 0017           F=DATAN(F)                                                  00090140
ISN 0018           F=2.D 00*F                                                  00090150
ISN 0019           F=ALLOT (F)                                                 00090160
ISN 0020         7 X1=1.0D0-A(2)*CE                                            00090170
ISN 0021         8 X2=1.0D0/X1                                                 00090180
ISN 0022         9 R=A(1)*X1                                                   00090190
```

```
ISN 0023            DUM1=1.0D0-A2**2                                        00090200
ISN 0024         10 X3=DSQRT(DUM1)                                          00090210
ISN 0025         11 RTGMA=DSQRT(GM*A1)                                      00090220
ISN 0026            SA = DSIN(A5)                                           00090230
ISN 0027            SB = DSIN(A3)                                           00090240
ISN 0028            SC = DSIN(A4)                                           00090250
ISN 0029            CA = DCOS(A5)                                           00090260
ISN 0030            CB = DCOS(A3)                                           00090270
ISN 0031            CC = DCOS(A4)                                           00090280
                 C                                                          00090290
                 C     COMPUTE POSITION COORDINATES                         00090300
                 C                                                          00090310
ISN 0032            Q1 = A(1)*(CE-A(2))                                     00090320
ISN 0033            Q2 = A(1)*X3*SE                                         00090330
ISN 0034            V  = Q1*CA - Q2*SA                                      00090340
ISN 0035            W  = Q2*CA + Q1*SA                                      00090350
ISN 0036            Z  = CB*W                                               00090360
ISN 0037            X(1) = CC*V - SC*Z                                      00090370
ISN 0038            X(2) = CC*Z + SC*V                                      00090380
ISN 0039            X(3) = SB*W                                             00090390
ISN 0040            RADV=DSQRT(X(1)**2+X(2)**2+X(3)**2)                     00090400
                 C                                                          00090410
                 C     COMPUTE VELOCITY COMPONENTS                          00090420
                 C                                                          00090430
ISN 0041            QD1 = -RTGMA*SE/R                                       00090440
ISN 0042            QD2 = RTGMA*X3*CE/R                                     00090450
ISN 0043            V = QD1*CA - QD2*SA                                     00090460
ISN 0044            W = QD2*CA + QD1*SA                                     00090470
ISN 0045            Z = CB*W                                                00090480
ISN 0046            VX(1) = CC*V - SC*Z                                     00090490
ISN 0047            VX(2) = CC*Z + SC*V                                     00090500
ISN 0048            VX(3) = SB*W                                            00090510
                 C                                                          00090520
ISN 0049            RTGM=DSQRT(GM)                                          00090530
ISN 0050            RTA=DSQRT(A1)                                           00090540
ISN 0051            EN=RTGM/(RTA*A(1))                                      00090550
ISN 0052            P=6.2831853071795860D0/EN                               00090560
ISN 0053            RETURN                                                  00090570
ISN 0054            END                                                     00090580
```

****F O R T R A N C R O S S R E F E R E N C E L I S T I N G****

SYMBOL	INTERNAL STATEMENT NUMBERS												
A	0002	0005	0006	0007	0008	0009	0010	0011	0020	0022	0032	0032	0033	0051
E	0002	0012	0013	0013	0015									
F	0002	0014	0015	0015	0016	0016	0017	0017	0018	0018	0019	0019		
P	0002	0052												
R	0022	0041	0042											
V	0034	0037	0038	0043	0044	0047								
W	0035	0036	0039	0044	0045	0048								
X	0002	0005	0037	0038	0039	0040	0040	0041						
Z	0038	0037	0036	0043	0046	0047								
A1	0006	0025	0050											
A2	0007	0012	0014	0014	0023									
A3	0008	0027	0031											
A4	0009	0028	0051											
A5	0010	0026	0029											
A6	0011	0012												
CA	0029	0034	0035	0043	0044									
CB	0030	0036	0045											
CC	0031	0037	0038	0046	0047									
CE	0012	0029	0034	0042										
EN	0002	0051	0052											
GM	0002	0025	0049											
Q1	0032	0034	0035											
Q2	0033	0034	0035											
SA	0026	0034	0035	0043	0044									
SB	0027	0036	0045											
SC	0028	0037	0038	0046	0047									
SE	0012	0033	0041											
VX	0002	0005	0040	0047	0048									
X1	0020	0021	0023											
X2	0021													
X3	0024	0033	0042											
ERR	0002	0012												
NIT	0002	0016												
QD1	0041	0043	0044											
QD2	0042	0043	0044											
RTA	0050	0051												
DCOS	0029	0030	0031											
DSIN	0026	0027	0028											
DTAN	0010													
DUM1	0021	0024												
ELRV	0002													
GDIF	0002	0012												
NMAX	0002	0012												
RALV	0002	0040												
RTGM	0049	0051												
XKEP	0012													
ALLOT	0013	0019												
DATAN	0017													
DSQRT	0015	0024	0025	0040	0044	0050								
RTGM	0025	0041	0042											

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
4	0012	
7	0020	
8	0021	
9	0022	
10	0024	
11	0025	
100	0004	

```
          COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
                SUBROUTINE HMSRZ                                                                    00097020
   ISN 0002             REAL FUNCTION HMSRZ*8(IH,IM,TS)                                             00097030
   ISN 0003             IMPLICIT REAL*8(A-H,O-Z,$)                                                  00097040
                C                                                                                   00097050
                C       VERSION OF 07/22/63                                                         00097060
                C            FORTRAN FUNCTION                                                       00097070
                C                                                                                   00097080
                C       PURPOSE                                                                     00097090
                C            CONVERTS HOURS, MINUTES, AND SECONDS OF TIME TO RADIANS                00097100
                C            (24 HOURS = 2 PI RADIANS).                                             00097110
                C                                                                                   00097120
                C       CALLING SEQUENCE                                                            00097130
                C        D      NAME = HMSRZ(IH,IM,TS)                                              00097140
                C                                                                                   00097150
                C       INPUT                                                                       00097160
                C            IH    = NUMBER OF HOURS IN TIME                                        00097170
                C            IM    = NUMBER OF MINUTES IN TIME                                      00097180
                C            TS    = NUMBER OF SECONDS IN TIME                                      00097190
                C                                                                                   00097200
                C                    SIGN OF THE INPUT TIME NEED ONLY BE ASSOCIATED WITH            00097210
                C                    THE NUMBER OF HOURS (IH).                                      00097220
                C                                                                                   00097230
                C       OUTPUT                                                                      00097240
                C            NAME = TIME IN RADIANS                                                 00097250
                C                                                                                   00097260
                C                    NAME IS RETURNED TO CALLING PROGRAM IN DOUBLE                  00097270
                C                    PRECISION FORM.                                                00097280
                C                                                                                   00097290
                C       REFERENCE                                                                   00097300
                C            ******                                                                 00097310
                C                                                                                   00097320
                C       METHOD                                                                      00097330
                C            ******                                                                 00097340
                C                                                                                   00097350
                C       RESTRICTIONS                                                                00097360
                C            ******                                                                 00097370
                C                                                                                   00097380
   ISN 0004       100 CONTINUE                                                                      00097390
                C       ACCURACY                                                                    00097400
                C            WHEN NECESSARY, INTERNAL ARITHMETIC IS PERFORMED IN DOUBLE             00097410
                C            PRECISION SO THAT THE VALUE OF THE OUTPUT ARGUMENT IS                  00097420
                C            AVAILABLE TO CALLING PROGRAM IN DOUBLE PRECISION.                      00097430
                C                                                                                   00097440
                C                                                                                   00097450
                C       REQUIRED SUBPROGRAMS                                                        00097460
                C            NONE                                                                   00097470
                C                                                                                   00097480
                C                                                                                   00097490
                C       TIMING                                                                      00097500
                C            NO ESTIMATE AVAILABLE                                                  00097510
                C                                                                                   00097520
                C                                                                                   00097530
                C                                                                                   00097540
                C                                                                                   00097550
```

```
                C***** START PROGRAM ***************************************************00097560
                C                                                                       00097570
ISN 0005            2 TH=IH                                                             00097580
ISN 0006            3 TM=IM                                                             00097590
ISN 0007            4 TM=DSIGN(TM,TH)                                                   00097600
ISN 0008            5 TRS=DSIGN(TS,TH)                                                  00097610
ISN 0009            6 HMSRZ=TH*.2E17953E77591494DC + TM*4.363231299858240-3             00097620
                     1         +TRS*7.272205216643040-5                                 00097630
ISN 0010              RETURN                                                            00097640
ISN 0011              END                                                               00097650
```

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS				
IH	0002	0005			
IM	0002	0006			
TH	0005	0007	0008	0009	
TM	0006	0007	0007	0009	
TS	0002	0008			
TRS	0008	0009			
CSIGN	0007	0008			
HMSRZ	0002	0009			

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
2	0005	
3	0006	
4	0007	
5	0008	
6	0009	
100	0004	

```
        COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
            CSUBROUTINE JULCAL                                                          00099560
ISN 0002            SUBROUTINE JULCAL(DJ,NM,ND,NY)                                  00099570
ISN 0003            IMPLICIT REAL*8(A-H,O-Z,$)                                      00099580
                C                                                                   00099590
                C     VERSION OF 07/22/63                                           00099600
                C           FORTRAN SUBROUTINE                                      00099610
                C                                                                   00099620
                C     PURPOSE                                                       00099630
                C           COMPUTES CALENDAR DATE FROM JULIAN DATE AT 0 HOURS       00099640
                C           UNIVERSAL TIME (OR 0 HOURS EPHEMERIS TIME).             00099650
                C                                                                   00099660
                C     CALLING SEQUENCE                                              00099670
                C           CALL JULCAL(DJ,NM,ND,NY)                                00099680
                C                                                                   00099690
                C     INPUT                                                         00099700
                C           DJ    = JULIAN DATE AT 0 HOURS UNIVERSAL TIME           00099710
                C                                                                   00099720
                C     OUTPUT                                                        00099730
                C           NM    = CALENDAR MONTH                                00099740
                C           ND    = CALENDAR DAY                                  00099750
                C           NY    = CALENDAR YEAR                                 00099760
                C                                                                   00099770
                C     REFERENCE                                                     00099780
                C           REFER TO MATHEMATICAL DESCRIPTION IN SUBPROGRAM WRITEUP 00099790
                C                                                                   00099800
                C     METHOD                                                        00099810
                C           THE NUMBER OF DAYS FROM 12 HOURS UNIVERSAL TIME JAN. 0, 00099820
                C           1800 IS CALCULATED.  THE INTEGRAL NUMBER OF YEARS IN THIS 00099830
                C           NUMBER IS ADDED TO 1800 TO GIVE THE CURRENT CALENDAR YEAR 00099840
                C           AND THE NUMBER OF DAYS CONTAINED IN THE INTEGRAL NUMBER  00099850
                C           OF YEARS ELAPSED SINCE JAN. 0, 1800 IS SUBTRACTED FROM THE 00099860
                C           ORIGINAL NUMBER OF DAYS FROM JAN. 0, 1800.  THE INTEGRAL 00099870
                C           NUMBER OF MONTHS IN THIS REMAINDER IS CALCULATED TO GIVE  00099880
                C           THE CURRENT CALENDAR MONTH.  THE NUMBER OF DAYS CONTAINED 00099890
                C           IN THIS INTEGRAL NUMBER OF MONTHS IS SUBTRACTED FROM THE  00099900
                C           PREVIOUS REMAINING DAYS TO GIVE THE CALENDAR DAY.         00099910
                C           APPROPIATE CONSIDERATION HAS BEEN GIVEN TO THOSE YEARS    00099920
                C           WHICH ARE DIVISIBLE BY 4, 100, AND 400.                   00099930
                C           APPROPIATE CONSIDERATION HAS BEEN GIVEN TO THOSE YEARS    00099940
                C           WHICH ARE DIVISIBLE BY 4, 100, AND 400.                   00099950
                C                                                                   00099960
                C     RESTRICTIONS                                                  00099970
                C           DATE RESTRICTED TO LIE BETWEEN JANUARY 1, 1801 AND DECEMBER00099980
                C           31, 2000.                                               00099990
SN 0004           100 CONTINUE                                                      00100000
                C                                                                   00100010
                C     ACCURACY                                                      00100020
                C           ******                                                  00100030
                C                                                                   00100040
                C                                                                   00100050
                C     REQUIRED SUBPROGRAMS                                          00100060
                C           07/22/63  DJUL                                          00100070
                C                     MAD                                           00100080
                C                                                                   00100090
```

```
                C                                                                       00100100
                C     TIMING                                                            00100110
                C             NO ESTIMATE AVAILABLE                                     00100120
                C                                                                       00100130
                C                                                                       00100140
                C                                                                       00100150
                C                                                                       00100160
                C***** START PROGRAM **************************************************00100170
                C                                                                       00100180
ISN 0005              DIMENSION M(12)                                                   00100190
ISN 0006            6 NM=0                                                            00100200
ISN 0007            8 M(1)=31                                                         00100210
ISN 0008            9 M(2)=28                                                         00100220
ISN 0009           10 M(3)=31                                                         00100230
ISN 0010           11 M(4)=30                                                         00100240
ISN 0011           12 M(5)=31                                                         00100250
ISN 0012           13 M(6)=30                                                         00100260
ISN 0013           14 M(7)=31                                                         00100270
ISN 0014           15 M(8)=31                                                         00100280
ISN 0015           16 M(9)=30                                                         00100290
ISN 0016           17 M(10)=31                                                        00100300
ISN 0017           18 M(11)=30                                                        00100310
ISN 0018           19 M(12)=31                                                        00100320
                C                                                                       00100330
ISN 0019           20 IF (DJ-2415020.5D0) 21,21,22                                    00100340
ISN 0020           21 NY=IDINT((DJ-2378495.5D0)/365.25D0)+1800                        00100350
ISN 0021              GO TO 23                                                        00100360
ISN 0022           22 NY=IDINT((DJ-2378495.5D0+1.0D0)/365.25D0)+1800                  00100370
ISN 0023           23 NDY=DJ-DJUL(1,0,NY)                                             00100380
ISN 0024           24 ND=NDY                                                          00100390
ISN 0025           25 DO 33 N=1,12                                                    00100400
ISN 0026           26 IF (N-2) 30,27,30                                               00100410
ISN 0027           27 IF (NY-1900)28,30,28                                            00100420
ISN 0028           28 IF ( MAD (NY,4)) 30,29,30                                       00100430
ISN 0029           29 M(N)=M(N)+1                                                     00100440
ISN 0030           30 ND=ND-M(N)                                                      00100450
ISN 0031           31 NM=NM+1                                                         00100460
ISN 0032           32 IF (ND) 34,34,33                                                00100470
ISN 0033           33 CONTINUE                                                        00100480
ISN 0034           34 ND=ND+M(N)                                                      00100490
ISN 0035              RETURN                                                          00100500
ISN 0036              END                                                             00100510
```

*****F O R T R A N C R O S S R E F E R E N C E L I S T I N G*****

SYMBOL	INTERNAL STATEMENT NUMBERS																
M	0005	0007	0008	0009	0010	0011	0012	0013	0014	0015	0016	0017	0018	0029	0029	0030	0034
N	0025	0026	0029	0029	0030	0034											
DJ	0002	0019	0020	0022	0023												
ND	0002	0024	0030	0030	0032	0034	0034										
NM	0002	0006	0031	0031													
NY	0002	0020	0022	0023	0027	0028											
MAD	0028																
NDY	0023	0024															
DJUL	0023																
IDINT	0020	0022															
JULCAL	0002																

*****F O R T R A N C R O S S R E F E R E N C E L I S T I N G*****

LABEL	DEFINED	REFERENCES
6	0006	
8	0007	
9	0008	
10	0009	
11	0010	
12	0011	
13	0012	
14	0013	
15	0014	
16	0015	
17	0016	
18	0017	
19	0018	
20	0019	
21	0020	0019 0019
22	0022	0019
23	0023	0021
24	0024	
25	0025	
26	0026	
27	0027	0026
28	0028	0027 0027
29	0029	0028
30	0030	0026 0026 0027 0028 0028
31	0031	
32	0032	
33	0033	0025 0032
34	0034	0032 0032
100	0004	

```
         COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
              CSUBROUTINE KOMEAN                                                                    00101310
   ISN 0002           SUBROUTINE KOMEAN(DN)                                                         00101320
   ISN 0003           IMPLICIT REAL*8(A-H,O-Z,$)                                                    00101330
                C                                                                                   00101340
                C     OUTPUT                                                                        00101350
                C          DN = REDUCTION OF MEAN MOTION OF MEAN ANOMALY FROM BROUWER TO00101360
                C               KOZAI IN RADIANS PER SECOND.                                        00101370
                C                                                                                   00101380
   ISN 0004           DIMENSION EM(16),EMCOEF(16,10),FJ(5),COEF(10)                                 00101390
   ISN 0005           DIMENSION DUM1(10C) ,DUM2(49)                                                 00101400
   ISN 0006           DIMENSION A110(6),GP(5),A11(6),A1(6),A(6),RX(3),VX(3),EL(13),F(9),00101410
                     1E(9),C(10),D(23),G(13),X(28),S(3)                                             00101420
   ISN 0007           DIMENSION TC(99),ARGC(99),ARGMOT(99),ARG(99),CCOEF(99,6),                     00101430
                     1SCOEF(99,6),DSUP(6),ASHORT(6)                                                 00101440
   ISN 0008           COMMON DUM1,A110,CP,ERR,A11,A1,A,RX,VX,ENO,ECA1,D1E,D1I,AL1,UL,               00101450
                     1   G1,UG,H1,UH,S,EL,A2,A3,B,C,D,G,X,F,DUM2,CMU,                              00101460
                     2                              T0,DJ0,DTIMES,ARG0,ARGMOT,ARG,CCOEF,           00101470
                     3SCOEF,DSUP,CJ2S,CJ3,CJ4,DLJ2S,DLJ3,DLJ4,DLSUM,DAJ2S,DAJ3,DAJ4,                00101480
                     4CASUM,REM , ASHORT,                                                           00101490
                     5           NBRWR1,NLONG,NSHORT,NSEC,NSECD,NSUPP,NSUPPD,NARG,KCOUNT00101500
                     6,NKOZ,NKOZD                                                                   00101510
   ISN 0009          1 FORMAT(6(1X,D21.14))                                                        00101520
   ISN 0010          2 FORMAT(1H1)                                                                 00101530
   ISN 0011          3 FORMAT(33X, 66HDETAILS OF COMPUTATION OF REDUCTION OF MEAN MOTION 00101540
                     1OF MEAN ANOMALY/36X,59HFROM VALUE ACCORDING TO BROUWER TO VALUE AC00101550
                     2CORDING TO KOZAI/45X,43HTHESE ARE DETAILS IN CURRENT ITERATION ONL00101560
                     3Y/27X,78HFOR IDENTIFICATIONS OF PRINTED VALUES SEE SOURCE LISTING 00101570
                     4FOR SUBROUTINE KOMEAN//)                                                      00101580
   ISN 0012           RE=REM*1.D 03                                                                 00101590
   ISN 0013           FJ(2)=2.D 00*GP(2)*RE**(-2)                                                   00101600
   ISN 0014           FJ(3)=-GP(3)*RE**(-3)                                                         00101610
   ISN 0015           FJ(4)=-(8.D 00/3.D 00)*GP(4)*RE**(-4)                                         00101620
   ISN 0016           SEMA=A110(1)/RE                                                               00101630
   ISN 0017           E=A110(2)                                                                     00101640
   ISN 0018           EPS=DSQRT(1.D 00-E**2)                                                        00101650
   ISN 0019           TH=DCOS(A110(3))                                                              00101660
   ISN 0020           P=SEMA*(1.D 00-E**2)                                                          00101670
   ISN 0021           DO 101 I=1,16                                                                 00101680
   ISN 0022           DO 101 J=1,10                                                                 00101690
   ISN 0023         101 EMCOEF(I,J)=0.D 00                                                          00101700
   ISN 0024           THSQ=TH*TH                                                                    00101710
   ISN 0025           EM0=1.D 00-5.D 00*THSQ                                                        00101720
   ISN 0026           EMCOEF( 2,1)=3.D 00                                                           00101730
   ISN 0027           EMCOEF( 2,2)=-3.D 00                                                          00101740
   ISN 0028           EMCOEF( 3,1)=1.D 00                                                           00101750
   ISN 0029           EMCOEF( 3,2)=-15.D 00                                                         00101760
   ISN 0030           EMCOEF( 4,1)=5.D 00                                                           00101770
   ISN 0031           EMCOEF( 4,2)=-35.D 00                                                         00101780
   ISN 0032           EMCOEF( 6,1)=1.D 00                                                           00101790
   ISN 0033           EMCOEF( 6,2)=-43.D 00                                                         00101800
   ISN 0034           EMCOEF( 6,3)=135.D 00                                                         00101810
   ISN 0035           EMCOEF( 6,4)=-225.D 00                                                        00101820
   ISN 0036           EMCOEF( 7,1)=10.D 00                                                          00101830
   ISN 0037           EMCOEF( 7,2)=-420.D 00                                                        00101840
```

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ISN 0038            EMCOEF( 7,3)=408C.D 00                                  00101850
ISN 0039            EMCOEF( 7,4)=-12700.D 00                                00101860
ISN 0040            EMCOEF( 7,5)=1575C.D 00                                 00101870
ISN 0041            EMCOEF( 8,1)=5.D 00                                     00101880
ISN 0042            EMCOEF( 8,2)=-95.D 00                                   00101890
ISN 0043            EMCOEF( 8,3)=375.D 00                                   00101900
ISN 0044            EMCOEF( 8,4)=-525.D 00                                  00101910
ISN 0045            EMCOEF( 9,1)=1.D 00                                     00101920
ISN 0046            EMCOEF( 9,2)=-1.D 00-2.D 00*E**2                        00101930
ISN 0047            EMCOEF(10,1)=512.D 00+768.D 00*E**2                     00101940
ISN 0048            EMCOEF(10,2)=-944.D 00-1248.D 00*E**2                   00101950
ISN 0049            EMCOEF(13,1)=4.D 00                                     00101960
ISN 0050            EMCOEF(13,2)=-127.D 00                                  00101970
ISN 0051            EMCOEF(13,3)=480.D 00                                   00101980
ISN 0052            EMCOEF(13,4)=-525.D 00                                  00101990
ISN 0053            EMCOEF(14,1)=40.D 00                                    00102000
ISN 0054            EMCOEF(14,2)=-1390.D 00                                 00102010
ISN 0055            EMCOEF(14,3)=1273C.D 00                                 00102020
ISN 0056            EMCOEF(14,4)=-38050.D 00                                00102030
ISN 0057            EMCOEF(14,5)=36750.D 00                                 00102040
ISN 0058            EMCOEF(15,1)=20.D 00                                    00102050
ISN 0059            EMCOEF(15,2)=-315.D 00                                  00102060
ISN 0060            EMCOEF(15,3)=1160.D 00                                  00102070
ISN 0061            EMCOEF(15,4)=-1225.D 00                                 00102080
ISN 0062            EMCOEF(16,1)=-2.D 00-2.D 00*E**2                        00102090
ISN 0063            EMCOEF(16,2)= 2.D 00+3.D 00*E**2                        00102100
ISN 0064            DO 102 I=1,16                                           00102110
ISN 0065            DO 199 J=1,10                                           00102120
ISN 0066        199 COEF(J)=EMCOEF(I,J)                                     00102130
ISN 0067        102 CALL POLVAL(4,COEF,THSQ,EM(I))                          00102140
ISN 0068            EM(1)=E*(1.D 00-THSQ)/EM0**2                            00102150
ISN 0069            EM(5)=2.D 00*E**2/EM0                                   00102160
ISN 0070            EM(6)=EM(6)*EM(3)                                       00102170
ISN 0071            EM(8)=EM(8)*EM(4)                                       00102180
ISN 0072            EM(9)=EM(9)/E                                           00102190
ISN 0073            EM(11)=(4.D 00/3.D 00)*EM(2)/EM0**2                     00102200
ISN 0074            EM(12)=E**2/EM0**3                                      00102210
ISN 0075            EM(13)=EM(13)*EM(3)                                     00102220
ISN 0076            EM(15)=EM(15)*EM(4)                                     00102230
ISN 0077            EM(16)=EM(16)*TH/DSQRT(1.D 00-THSQ)                     00102240
ISN 0078            IF(NKOZD)7001,7002,7001                                 00102250
ISN 0079        7001 WRITE(6,2)                                             00102260
ISN 0080             WRITE(6,3)                                             00102270
ISN 0081             WRITE(6,1)(EM(I),I=1,16)                               00102280
ISN 0082        7002 DE1=EM(3)+FJ(4)*EM(4)/FJ(2)                            00102290
ISN 0083             IF(NKOZD)7003,7004,7003                                00102300
ISN 0084        7003 WRITE(6,1)DE1                                          00102310
ISN 0085        7004 DE1=DE1**2                                             00102320
ISN 0086             IF(NKOZD)7005,7006,7005                                00102330
ISN 0087        7005 WRITE(6,1)DE1                                          00102340
ISN 0088        7006 DE1=EM(2)*DE1                                          00102350
ISN 0089             IF(NKOZD)7007,7008,7007                                00102360
ISN 0090        7007 WRITE(6,1)DE1                                          00102370
ISN 0091        7008 DE2=FJ(4)/FJ(2)**2                                     00102380
ISN 0092             IF(NKOZD)7009,701C,7009                                00102390
ISN 0093        7009 WRITE(6,1)DE2                                          00102400
```

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ISN 0094      7010 DE3=EM(6)+EM(7)*DE2+EM(8)*DE2**2                                    00102410
ISN 0095           IF(NKOZD)7011,7012,7011                                           00102420
ISN 0096      7011 WRITE(6,1)DE3                                                     00102430
ISN 0097      7012 DE=DE1+EM(5)*DE3                                                  00102440
ISN 0098           IF(NKOZD)7013,7014,7013                                           00102450
ISN 0099      7013 WRITE(6,1)DE                                                      00102460
ISN 0100      7014 DE=EM(1)*DE                                                       00102470
ISN 0101           IF(NKOZD)7015,7016,7015                                           00102480
ISN 0102      7015 WRITE(6,1)DE                                                      00102490
ISN 0103      7016 DE=(FJ(2)**2/(1024.D 00*SEMA  *P**3))*DE                          00102500
ISN 0104           IF(NKOZD)7017,7018,7017                                           00102510
ISN 0105      7017 WRITE(6,1)DE                                                      00102520
ISN 0106      7018 DE4=                                                              00102530
                  1 ((FJ(3)**2/FJ(2)**2)/(16.D 00*SEMA*P))*EM(9)                   00102540
ISN 0107           IF(NKOZD)7019,7020,7019                                           00102550
ISN 0108      7019 WRITE(6,1)DE4                                                     00102560
ISN 0109      7020 DE=DE+DE4                                                         00102570
ISN 0110           DI1=EM(10)+EM(11)*(EM(3)+EM(4)*FJ(4)/FJ(2)**2)**2                 00102580
ISN 0111           IF(NKOZD)7021,7022,7021                                           00102590
ISN 0112      7021 WRITE(6,1)DI1                                                     00102600
ISN 0113      7022 DI2=EM(12)*(EM(13)+EM(14)*FJ(4)/FJ(2)+EM(15)*(FJ(4)/FJ(2))**2)    00102610
ISN 0114           IF(NKOZD)7023,7024,7023                                           00102620
ISN 0115      7023 WRITE(6,1)DI2 ,A110(3)                                            00102630
ISN 0116      7024 DI3=(FJ(2)**2/(2048.D 00*P**4))*DSIN(2.D 00*A110(3))              00102640
ISN 0117           IF(NKOZD)7025,7026,7025                                           00102650
ISN 0118      7025 WRITE(6,1)DI3                                                     00102660
ISN 0119      7026 DI4=(FJ(3)/FJ(2))**2/(16.D 00*P**2)                               00102670
ISN 0120           IF(NKOZD)7027,7028,7027                                           00102680
ISN 0121      7027 WRITE(6,1)DI4                                                     00102690
ISN 0122      7028 DI4=DI4*EM(16)                                                    00102700
ISN 0123           IF(NKOZD)7029,7030,7029                                           00102710
ISN 0124      7029 WRITE(6,1)DI4                                                     00102720
ISN 0125      7030 DI=-DI3*(DI1+DI2)+DI4                                             00102730
ISN 0126           DTH=-DSIN(A110(3))*DI                                             00102740
ISN 0127           IF(NKOZD)7031,7032,7031                                           00102750
ISN 0128      7031 WRITE(6,1)(FJ(I),I=2,4),SEMA,P                                    00102760
ISN 0129           WRITE(6,1)DE,DI,DTH                                               00102770
ISN 0130      7032 GAMMA=0.75D 00*P**(-2)*EPS*(1.D 00-3.D 00*THSQ)                   00102780
ISN 0131           B220=-15.D 00+16.D 00*EPS+25.D 00*EPS**2                          00102790
ISN 0132           B221=30.D 00-96.D 00*EPS-90.D 00*EPS**2                           00102800
ISN 0133           B222=105.D 00+144.D 00*EPS+25.D 00*EPS**2                         00102810
ISN 0134           IF(NKOZD)7033,7034,7033                                           00102820
ISN 0135      7033 WRITE(6,1)GAMMA,B220,B221,B222                                    00102830
ISN 0136      7034 B22=B220+B221*THSQ+B222*THSQ**2                                   00102840
ISN 0137           IF(NKOZD)7035,7036,7035                                           00102850
ISN 0138      7035 WRITE(6,1)B22                                                     00102860
ISN 0139      7036 B22=(3.D 00/128.D 00)*EPS*B22                                     00102870
ISN 0140           IF(NKOZD)7037,7038,7037                                           00102880
ISN 0141      7037 WRITE(6,1)B22                                                     00102890
ISN 0142      7038 B4=3.D 00-30.D 00*THSQ+35.D 00*THSQ**2                            00102900
ISN 0143           IF(NKOZD)7039,7040,7039                                           00102910
ISN 0144      7039 WRITE(6,1)B4                                                      00102920
ISN 0145      7040 B4=-(45.D 00/128.D 00)*EPS*E**2*B4                                00102930
ISN 0146           IF(NKOZD)7041,7042,7041                                           00102940
ISN 0147      7041 WRITE(6,1)B4                                                      00102950
ISN 0148      7042 B22=B22*P**(-4)                                                   00102960
```

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ISN 0149            B4=B4*P**(-4)                                                    00102970
ISN 0150            IF(NKOZD)7043,7044,7043                                          00102980
ISN 0151       7043 WRITE(6,1)B22,B4                                                 00102990
ISN 0152       7044 DN1=FJ(2)**3*(GAMMA**3-4.D 00*GAMMA*B22)                         00103000
ISN 0153            DN2=-4.D 00*B4*GAMMA*FJ(2)*FJ(4)                                 00103010
ISN 0154            DN3=3.D 00*E*EPS**(-2)*FJ(2)*DE                                  00103020
ISN 0155            DN4=(-6.D 00*TH/(1.D 00-3.D 00*THSQ))*FJ(2)*DTH                  00103030
ISN 0156            DNN0=DN1+DN2+DN3+DN4                                             00103040
ISN 0157            DN=ENO*DNN0                                                      00103050
ISN 0158            IF(NKOZD)7045,7046,7045                                          00103060
ISN 0159       7045 WRITE(6,1)DN1,DN2,DN3,DN4,DNN0,ENO,DN                            00103070
ISN 0160       7046 RETURN                                                           00103080
ISN 0161            END                                                              00103090
```

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS
A	0006 0008
B	0006 0008
C	0006 0008
D	0006 0008
E	0017 0018 0020 0046 0047 0048 0062 0063 0068 0069 0072 0074 0145 0154
F	0006 0008
G	0006 0008
I	0021 0023 0064 0066 0067 0081 0081 0081 0128 0128 0128
J	0022 0023 0065 0066 0066
P	0020 0103 0106 0116 0119 0128 0130 0148 0149
S	0006 0008
X	0006 0008
A1	0006 0008
A2	0008
A3	0008
B4	0142 0144 0145 0145 0147 0149 0149 0151 0153
DE	0097 0099 0100 0100 0102 0103 0103 0105 0109 0109 0129 0154
DI	0125 0126 0129
DN	0002 0157 0159
EL	0006 0008
EM	0004 0067 0068 0069 0070 0070 0070 0071 0071 0071 0072 0072 0073 0073 0074 0075 0075 0075 0076
	0076 0076 0077 0077 0081 0082 0082 0088 0094 0094 0094 0097 0100 0106 0110 0110 0110 0110 0113
	0113 0113 0113 0122
FJ	0004 0013 0014 0015 0082 0082 0091 0091 0103 0106 0106 0110 0110 0113 0113 0113 0113 0116 0119
	0119 0128 0152 0153 0153 0154 0155
GP	0006 0008 0013 0014 0015
G1	0008
H1	0008
RE	0012 0013 0014 0015 0016
RX	0006 0008
TH	0019 0024 0024 0077 0155
TO	0007 0008
UG	0008
UH	0008
UL	0008
VX	0006 0008
AL1	0008
ARG	0007 0008
A11	0006 0008
B22	0136 0138 0139 0139 0141 0148 0148 0151 0152
CJ3	0008
CJ4	0008
CMU	0008
DE1	0082 0084 0085 0085 0087 0088 0088 0090 0097
DE2	0091 0093 0094 0094
DE3	0094 0096 0097
DE4	0106 0108 0109
DI1	0110 0112 0125
DI2	0113 0115 0125
DI3	0116 0118 0125
DI4	0119 0121 0122 0122 0124 0125
DJ0	0008
DN'	0152 0156 0159
DN2	0153 0156 0159

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS
DN3	0154 0156 0159
DN4	0155 0156 0159
DTH	0126 0129 0155
D1E	0008
D1I	0008
EM0	0025 0068 0069 0073 0074
EN0	0008 0157 0159
EPS	0018 0130 0131 0131 0132 0132 0133 0133 0139 0145 0154
ERR	0008
GEM	0008 0012
ARG0	0007 0008
A110	0006 0008 0016 0017 0019 0115 0116 0126
B220	0131 0135 0136
B221	0132 0135 0136
B222	0133 0135 0136
CJ2S	0008
COEF	0004 0066 0067
DAJ3	0008
DAJ4	0008
DCOS	0019
DLJ3	0008
DLJ4	0008
DNN0	0156 0157 0159
DSIN	0116 0126
DSUP	0007 0008
DUM1	0005 0008
DUM2	0005 0008
ECA1	0008
NARG	0008
NKOZ	0008
NSEC	0008
SEMA	0016 0020 0103 0106 0128
THSQ	0024 0025 0067 0068 0077 0130 0136 0136 0142 0142 0155
CCOEF	0007 0008
DAJ2S	0008
DASUM	0008
DLJ2S	0008
DLSUM	0008
DSQRT	0018 0077
GAMMA	0130 0135 0152 0152 0153
NKOZD	0008 0078 0083 0086 0089 0092 0095 0098 0101 0104 0107 0111 0114 0117 0120 0123 0127 0134 0137
	0140 0143 0146 0150 0158
NLONG	0008
NSECD	0008
NSUPP	0008
SCOEF	0007 0008
ARGMOT	0007 0008
ASHORT	0007 0008
DTIMES	0008
EMCOEF	0004 0023 0026 0027 0028 0029 0030 0031 0032 0033 0034 0035 0036 0037 0038 0039 0040 0041 0042
	0043 0044 0045 0046 0047 0048 0049 0050 0051 0052 0053 0054 0055 0056 0057 0058 0059 0060 0061
	0062 0063 0066
KCOUNT	0008
KCMEAN	0002

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS
NBR#R1	0008
NSHORT	0008
NSUPPD	0008
PGLVAL	0067

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES																
1	0009	0081	0084	0087	0090	0093	0096	0099	0102	0105	0108	0112	0115	0118	0121	0124	0128	0129
		0135	0138	0141	0144	0147	0151	0159										
2	0010	0079																
3	0011	0080																
101	0023	0021	0022															
102	0067	0064																
199	0066	0065																
7001	0079	0078	0078															
7002	0082	0078																
7003	0084	0083	0083															
7004	0085	0083																
7005	0087	0086	0086															
7006	0088	0086																
7007	0090	0089	0089															
7008	0091	0089																
7009	0093	0092	0092															
7010	0094	0092																
7011	0096	0095	0095															
7012	0097	0095																
7013	0099	0098	0098															
7014	0100	0098																
7015	0102	0101	0101															
7016	0103	0101																
7017	0105	0104	0104															
7018	0106	0104																
7019	0108	0107	0107															
7020	0109	0107																
7021	0112	0111	0111															
7022	0113	0111																
7023	0115	0114	0114															
7024	0116	0114																
7025	0118	0117	0117															
7026	0119	0117																
7027	0121	0120	0120															
7028	0122	0120																
7029	0124	0123	0123															
7030	0125	0123																
7031	0128	0127	0127															
7032	0130	0127																
7033	0135	0134	0134															
7034	0136	0134																
7035	0138	0137	0137															
7036	0139	0137																
7037	0141	0140	0140															
7038	0142	0140																
7039	0144	0143	0143															
7040	0145	0143																
7041	0147	0146	0146															
7042	0148	0146																
7043	0151	0150	0150															
7044	0152	0150																
7045	0159	0158	0158															
7046	0160	0158																

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          COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
              CSUBROUTINE MAD                                                                    00109960
   ISN 0002           FUNCTION MAD(I,J)                                                          00109970
   ISN 0003           IMPLICIT REAL*8(A-H,O-Z,$)                                                 00109980
   ISN 0004           IF(J.EQ.0)GO TO 10                                                         00109990
   ISN 0006           K=I/J                                                                      00110000
   ISN 0007           MAD=I-K*J                                                                  00110010
   ISN 0008           RETURN                                                                     00110020
   ISN 0009        10 MAD=0                                                                      00110030
   ISN 0010           RETURN                                                                     00110040
   ISN 0011           END                                                                        00110050
```

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS			
I	0002	0006	0007	
J	0002	0004	0006	0007
K	0006	0007		
MAD	0002	0007	0009	

*****F O R T R A N C R O S S R E F E R E N C E L I S T I N G*****

LABEL	DEFINED	REFERENCES
10	0009	0004

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          COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
                SUBROUTINE PARA                                                                    00117050
   ISN 0002           SUBROUTINE PARA(INPUT,AI,A,GM,GDIF,NMAX,NIT,NSHORT,DN)                       00117060
   ISN 0003           IMPLICIT REAL*8(A-H,O-Z,$)                                                   00117070
                C                                                                                  00117080
                C     VERSION OF 06/14/63                                                          00117090
                C           FORTRAN SUBROUTINE                                                     00117100
                C                                                                                  00117110
                C     PURPOSE                                                                      00117120
                C           CONVERTS AN ARBITRARY SET OF 6 INDEPENDENT INPUT PARAMETERS            00117130
                C           INTO OSCULATING ORBITAL ELEMENTS.                                      00117140
                C                                                                                  00117150
                C     CALLING SEQUENCE                                                             00117160
                C           CALL PARA(INPUT,AI,A,GM,GDIF,NMAX,NIT,NSHORT,DN)                       00117170
                C                                                                                  00117180
                C           INPUT, OUTPUT, AND INTERNAL ARITHMETIC OPERATIONS ARE ALL              00117190
                C           PERFORMED IN DOUBLE PRECISION.                                         00117200
                C                                                                                  00117210
                C     INPUT                                                                        00117220
                C           INPUT= CONTROL NUMBER TO INDICATE TYPE OF INPUT PARAMETERS             00117230
                C           AI   = ARRAY OF 6 INDEPENDENT INPUT PARAMETERS                         00117240
                C           GM   = THE PRODUCT OF G, THE GAUSSIAN CONSTANT SQUARED,                00117250
                C                  AND M, THE MASS OF THE EARTH                                    00117260
                C           NMAX  = MAXIMUM NUMBER OF ITERATIONS ALLOWED                           00117270
                C                                                                                  00117280
                C     OUTPUT                                                                       00117290
                C           OSCULATING ORBITAL ELEMENTS                                            00117300
                C                                                                                  00117310
                C           A(1) = SEMI-MAJOR AXIS                                                 00117320
                C           A(2) = ECCENTRICITY                          - DIMENSIONLESS           00117330
                C           A(3) = INCLINATION                           - RADIANS                 00117340
                C           A(4) = RIGHT ASCENSION OF ASCENDING NODE     - RADIANS                 00117350
                C           A(5) = ARGUMENT OF PERIGEE                   - RADIANS                 00117360
                C           A(6) = MEAN ANOMALY                          - RADIANS                 00117370
                C           GDIF  = LAST CORRECTION (E2-E1)/E2                                     00117380
                C                   IN SOLVING KEPLER'S EQUATION.                                  00117390
                C           NIT   = SERIAL NUMBER OF CURRENT ITERATION IN SOLVING                  00117400
                C                   KEPLER'S EQUATION                                              00117410
                C         NSHORT  SHORT-PERIOD PERTURBATIONS INCLUDED  (  00 = NO                 00117420
                C                                                    LT.0                          00117430
                C                              THE SHORT PERIOD PERTURBATIONS ARE                  00117440
                C                              COMPUTED WITH E" AND I" .                           00117450
                C                                                    GT.0                          00117460
                C                              THE SHORT PERIOD PERTURBATIONS ARE                  00117470
                C                              COMPUTED WITH E' AND I' .          )                00117480
                C           DN = REDUCTION OF MEAN MOTION OF MEAN ANOMALY FROM BROUWER TO          00117490
                C                KOZAI IN RADIANS PER SECOND.                                      00117500
                C                                                                                  00117510
                C     REFERENCE                                                                    00117520
                C           ******                                                                 00117530
                C                                                                                  00117540
                C     METHOD                                                                       00117550
                C           ******                                                                 00117560
                C                                                                                  00117570
                C     RESTRICTIONS                                                                 00117580
```

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C                 ******                                                  00117590
C                                                                         00117600
C       ACCURACY                                                          00117610
C                 ******                                                  00117620
C                                                                         00117630
ISN 0004      100 CONTINUE                                                00117640
C       REQUIRED SUBPROGRAMS                                              00117650
C                 07/17/63  ERMR1                                         00117660
C                 01/31/64  RLWR2                                         00117670
C                           ERMR4                                         00117680
C                 07/02/63  RVELZ                                         00117690
C                                                                         00117700
C                                                                         00117710
C       TIMING                                                            00117720
C                 NO ESTIMATE AVAILABLE                                   00117730
C                                                                         00117740
C       ANALYSIS                                                          00117750
C                                                                         00117760
C                                                                         00117770
C                                                                         00117780
C***** START PROGRAM ***********************************************      00117790
C                                                                         00117800
ISN 0005          DIMENSION AI(6),A(6),RX(3),VX(3)                        00117810
ISN 0006          DIMENSION DUM1(100),A110(6)                             00117820
ISN 0007          DIMENSION XX(18),AB(6)                                  00117830
C                                                                         00117840
ISN 0008          COMMON TUM1,A110,XX,AB                                  00117850
ISN 0009          COMMON /LABEL1/ REML,TUM                                00117860
C                                                                         00117870
ISN 0010        302 GO TO (1,2,3,4), INPUT                                00117880
C       INPUT OPTION 1.  AI = OSCULATING ORBITAL ELEMENTS, ALL ANGLES IN  00117890
C                           DEGREES                                       00117900
C                                                                         00117910
ISN 0011          1 A(1)=AI(1)                                            00117920
ISN 0012            A(2)=AI(2)                                            00117930
ISN 0013            DO 101 N=3,6                                          00117940
ISN 0014        101 A(N)=AI(N)*0.01745329251994330D                       00117950
ISN 0015            GO TO 9999                                            00117960
C                                                                         00117970
C       INPUT OPTION 2.  AI = POSITION AND VELOCITY VECTORS IN            00117980
C                           KILOMETERS AND KILOMETERS/SECOND              00117990
C                                                                         00118000
ISN 0016          2 DO 201 N=1,3                                          00118010
ISN 0017            RX(N)=AI(N)                                           00118020
ISN 0018        201 VX(N)=AI(N+3)                                         00118030
ISN 0019            CALL RVELZ(RX,VX,A,PER,EN,GM)                         00118040
ISN 0020            GO TO 9999                                            00118050
C                                                                         00118060
C       INPUT OPTION 3.  AI = POSITION AND VELOCITY VECTORS IN            00118070
C                           VANGUARD UNITS                                00118080
C                                                                         00118090
ISN 0021          3 DO 301 N=1,3                                          00118100
ISN 0022            RX(N)=AI(N)*REML*1.D 03                               00118110
ISN 0023        301 VX(N)=AI(N+3)*(REML/TUM)*(1.D 00/3.6D 00)             00118120
ISN 0024            CALL RVELZ(RX,VX,A,PER,EN,GM)                         00118130
```

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ISN 0025          GO TO 9999                                                    CC118150
                                                                                CC118160
C.C.              INPUT OPTION 4.  AI = PROPER MEAN ELEMENTS, ALL ANGLES IN DEGREESCC118170
                                                                                CC118180
ISN 0026        4 A110(1)=AI(1)                                                 CC118190
ISN 0027          A110(2)=AI(2)                                                 CC118200
ISN 0028          DO 401 N=3,6                                                  CC118210
ISN 0029          EA=AI(N)*0.01745329251994330C                                 CC118220
ISN 0030        401 A110(N)=EA                                                  CC118230
ISN 0031          CALL EE*RI(ON)                                                CC118240
ISN 0032          DT=0.CCC                                                      CC118250
ISN 0033          IF(NSMORT)410,410,411                                         CC118260
ISN 0034        410 CALL EE**2(DT,      E,F,RADV,GLIF,NMAX,NIT)                 CC118270
ISN 0035          GO TO 412                                                     CC118280
ISN 0036        411 CALL EE**4(DT,      E,F,RADV,GLIF,NMAX,NIT)                 CC118290
ISN 0037        412 DO 402 N=1,6                                                CC118300
ISN 0038        402 A(N)=A0(N)                                                  CC118310
ISN 0039       9999 RETURN                                                      CC118320
ISN 0040            END                                                         CC118330
```

**** F O R T R A N C R O S S R E F E R E N C E L I S T I N G ****

SYMBOL	INTERNAL STATEMENT NUMBERS																			
A	0002	0005	0011	0012	0014	0019	0024	0038												
E	0034	0036																		
F	0034	0036																		
N	0013	0014	0014	0016	0017	0017	0018	0018	0021	0022	0022	0023	0023	0028	0029	0030	0037	0038	0038	
AB	0007	0008	0038																	
AI	0002	0005	0011	0012	0014	0017	0018	0022	0023	0026	0027	0029								
BA	0029	0030																		
DN	0002	0031																		
DT	0032	0034	0036																	
EN	0019	0024																		
GM	0002	0019	0024																	
RX	0005	0017	0019	0022	0024															
VX	0005	0018	0019	0023	0024															
XX	0007	0008																		
NIT	0002	0034	0036																	
PER	0019	0024																		
TUH	0009	0023																		
A110	0006	0008	0026	0027	0030															
DUM1	0006	0008																		
GDIF	0002	0034	0036																	
NMAX	0002	0034	0036																	
PARA	0002																			
RADV	0034	0036																		
REML	0009	0022	0023																	
ERRR1	0031																			
ERRR2	0034																			
ERRR4	0036																			
INPUT	0002	0010																		
RVELZ	0019	0024																		
NSHORT	0002	0033																		

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
1	0011	0010
2	0016	0010
3	0021	0010
4	0026	0010
100	0004	
101	0014	0013
201	0018	0016
301	0023	0021
302	0010	
401	0030	0028
402	0038	0037
410	0034	0033 0033
411	0036	0033
412	0037	0035
9999	0039	0015 0020 0025

```
          COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
              CSUBROUTINE POLVAL                                                                    00137200
   ISN 0002           SUBROUTINE POLVAL(N,A,X,Y)                                                    00137210
   ISN 0003           IMPLICIT REAL*8(A-H,O-Z,$)                                                    00137220
   ISN 0004           DIMENSION A(10)                                                               00137230
   ISN 0005         1 FORMAT(14H N NEGATIVE : I5)                                                   00137240
   ISN 0006         2 FORMAT(21H N GREATER THAN  9 = I5)                                            00137250
   ISN 0007        21 FORMAT(1X,I5)                                                                 00137260
   ISN 0008        22 FORMAT(1X,2I3,3D15.8)                                                         00137270
   ISN 0009           IF(N) 3,4,4                                                                   00137280
   ISN 0010         3 WRITE(6,1)N                                                                   00137290
   ISN 0011           STOP                                                                          00137300
   ISN 0012         4 IF(N-9) 6,6,5                                                                 00137310
   ISN 0013         5 WRITE(6,2)N                                                                   00137320
   ISN 0014           STOP                                                                          00137330
   ISN 0015         6 K = N + 1                                                                     00137340
   ISN 0016           CALL SSWTCH(1,K000FX)                                                         00137350
   ISN 0017           GO TO(7,8),K000FX                                                             00137360
   ISN 0018         7 WRITE (6,21)K                                                                 00137370
   ISN 0019         8 Y = 0.0D0                                                                     00137380
   ISN 0020           DO 11 I = 1,K                                                                 00137390
   ISN 0021           L = K - I + 1                                                                 00137400
   ISN 0022         9 Y = X * Y + A (L)                                                             00137410
   ISN 0023           CALL SSWTCH(1,K00CFX)                                                         00137420
   ISN 0024           GO TO(10,11),K00CFX                                                           00137430
   ISN 0025        10 WRITE (6,22)I,L,A(L),X,Y                                                      00137440
   ISN 0026        11 CONTINUE                                                                      00137450
   ISN 0027        12 RETURN                                                                        00137460
   ISN 0028           END                                                                           00137470
```

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS					
A	0002	0004	0022	0025		
I	0020	0021	0025			
K	0015	0018	0020	0021		
L	0021	0022	0025	0025		
N	0002	0009	0010	0012	0013	0015
X	0002	0022	0025			
Y	0002	0019	0022	0022	0025	
K000FX	0016	0017	0023	0024		
POLVAL	0002					
SSWTCH	0016	0023				

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES	
1	0005	0010	
2	0006	0013	
3	0010	0009	
4	0012	0009	0009
5	0013	0012	
6	0015	0012	0012
7	0018	0017	
8	0019	0017	
9	0022		
10	0025	0024	
11	0026	0020	0024
12	0027		
21	0007	0018	
22	0008	0025	

```
         COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
               SUBROUTINE RHMSZ                                                                  00142440
   ISN 0002          SUBROUTINE RHMSZ(TR,ID,IH,IM,TS)                                           00142450
   ISN 0003          IMPLICIT REAL*8(A-H,O-Z,$)                                                 00142460
                C                                                                               00142470
                C     VERSION OF 03/02/64                                                       00142480
                C           FORTRAN SUBROUTINE                                                  00142490
                C                                                                               00142500
                C     PURPOSE                                                                   00142510
                C           CONVERTS TIME IN RADIANS (24 HOURS = 2 PI RADIANS) INTO             00142520
                C           THE INTEGRAL NUMBER OF DAYS, NUMBER OF HOURS, NUMBER OF             00142530
                C           MINUTES, AND NUMBER OF SECONDS AND DECIMALS OF A SECOND             00142540
                C           CONTAINED IN THE TIME.                                              00142550
                C                                                                               00142560
                C     CALLING SEQUENCE                                                          00142570
                C      D      CALL RHMSZ(TR,ID,IH,IM,TS)                                        00142580
                C                                                                               00142590
                C     INPUT                                                                     00142600
                C           TR    = TIME IN RADIANS                                           00142610
                C                                                                               00142620
                C                   TIME MUST BE AVAILABLE IN CALLING PROGRAM IN                00142630
                C                   DOUBLE PRECISION FORM.                                      00142640
                C                                                                               00142650
                C     OUTPUT                                                                    00142660
                C           ID    = INTEGRAL NUMBER OF DAYS CONTAINED IN THE TIME             00142670
                C           IH    = NUMBER OF HOURS                                           00142680
                C           IM    = NUMBER OF MINUTES                                         00142690
                C           TS    = NUMBER OF SECONDS AND DECIMALS OF A SECOND                00142700
                C                                                                               00142710
                C     REFERENCE                                                                 00142720
                C           ******                                                              00142730
                C                                                                               00142740
                C     METHOD                                                                    00142750
                C           ******                                                              00142760
                C                                                                               00142770
                C     RESTRICTIONS                                                              00142780
                C           ******                                                              00142790
                C                                                                               00142800
                C     ACCURACY                                                                  00142810
                C           CONVERSION IS ACCURATE TO AT LEAST .001 SECONDS OF TIME.            00142820
                C                                                                               00142830
                C                                                                               00142840
                C     REQUIRED SUBPROGRAMS                                                      00142850
                C           NONE                                                                00142860
                C                                                                               00142870
                C                                                                               00142880
   ISN 0004       100 CONTINUE                                                                  00142890
                C     TIMING                                                                    00142900
                C           NO ESTIMATE AVAILABLE                                               00142910
                C                                                                               00142920
                C     ANALYSIS                                                                  00142930
                C                                                                               00142940
                C                                                                               00142950
                C***** START PROGRAM ***************************************************       00142960
                C                                                                               00142970
```

```
ISN 0005          5 ID=TR/6.2831853C7179586D0                                    00142980
ISN 0006            GDR=DFLOAT(ID)                                               00142990
ISN 0007            TR=TR-GDR*6.283185307179586D0                                00143000
ISN 0008          7 IH=TR*3.819718634205480D0                                    00143010
ISN 0009          8 T1=IH                                                        00143020
ISN 0010          9 A=T1/3.819718634205480D0                                     00143030
ISN 0011         10 B=TR-A                                                       00143040
ISN 0012         11 IM=B*229.183118052329D0                                      00143050
ISN 0013         12 T2=IM                                                        00143060
ISN 0014         13 IM=IABS (IM)                                                 00143070
ISN 0015         14 C=T2/229.183118052329D0                                      00143080
ISN 0016         15 D=B-C                                                        00143090
ISN 0017         16 TS=DABS(D*13750.9E70831397D0)                                00143100
ISN 0018         27 IF(DABS(TS)-.0005D0) 28,17,17                                00143110
ISN 0019         28 TS=0.D0                                                      00143120
ISN 0020         17 IF (TS-59.9995D0) 20,18,18                                   00143130
ISN 0021         18 TS=DABS(TS-60.D0)                                            00143140
ISN 0022         19 IM=IM+1                                                      00143150
ISN 0023            GO TO 27                                                     00143160
ISN 0024         20 IF (IM-60) 23,21,21                                          00143170
ISN 0025         21 IM=IM-60                                                     00143180
ISN 0026         22 IH=IH+ISIGN (1,IH)                                           00143190
ISN 0027         23 IF (IABS (IH)-24) 26,24,24                                   00143200
ISN 0028         24 IH=IH-ISIGN (24,IH)                                          00143210
ISN 0029         25 ID=ID+ISIGN (1,ID)                                           00143220
ISN 0030         26 RETURN                                                       00143230
ISN 0031            END                                                          00143240
```

*****F O R T R A N C R O S S R E F E R E N C E L I S T I N G*****

SYMBOL	INTERNAL STATEMENT NUMBERS									
A	0010	0011								
B	0011	0012	0016							
C	0015	0016								
D	0016	0017								
ID	0002	0005	0006	0029	0029	0029				
IH	0002	0008	0009	0026	0026	0026	0027	0028	0028	0028
IM	0002	0012	0013	0014	0014	0022	0022	0024	0025	0025
IR	0002	0005	0007	0007	0008	0011				
IS	0002	0017	0018	0019	0020	0021	0021			
I1	0009	0010								
I2	0013	0015								
GDR	0006	0007								
GABS	0017	0018	0021							
IABS	0014	0027								
ISIGN	002E	0028	0029							
FHMSZ	0002									
GFLOAT	0006									

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES	
5	0005		
7	0008		
8	0009		
9	0010		
10	0011		
11	0012		
12	0013		
13	0014		
14	0015		
15	0016		
16	0017		
17	0020	0018	0018
18	0021	0020	0020
19	0022		
20	0024	0020	
21	0025	0024	0024
22	0026		
23	0027	0024	
24	0028	0027	0027
25	0029		
26	0030	0027	
27	0018	0023	
28	0019	0018	
100	0004		

```
         COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
               SUBROUTINE RVELZ                                                                  00144060
ISN 0002             SUBROUTINE RVELZ(X,VX,A,P,EN,GM)                                          00144070
ISN 0003             IMPLICIT REAL*8(A-H,O-Z,$)                                                00144080
                     C                                                                         00144090
                     C      VERSION OF 07/22/63                                                00144100
                     C            FORTRAN SUBROUTINE                                           00144110
                     C                                                                         00144120
                     C      PURPOSE                                                            00144130
                     C            CONVERTS GEOCENTRIC EQUATORIAL INERTIAL RECTANGULAR          00144140
                     C            COORDINATES OF POSITION AND COMPONENTS OF VELOCITY INTO       00144150
                     C            OSCULATING ORBITAL ELEMENTS                                  00144160
                     C                                                                         00144170
                     C      CALLING SEQUENCE                                                   00144180
                     C            CALL RVELZ(X,VX,A,P,EN,GM)                                   00144190
                     C                                                                         00144200
                     C                                                                         00144210
                     C      INPUT                                                              00144220
                     C            X(1)                                                         00144230
                     C            X(2)   THE 3 RECTANGULAR COORDINATES OF POSITION             00144240
                     C            X(3)                                                         00144250
                     C                                                                         00144260
                     C            VX(1)                                                        00144270
                     C            VX(2)  THE 3 RECTANGULAR COMPONENTS OF VELOCITY              00144280
                     C            VX(3)                                                        00144290
                     C                                                                         00144300
                     C            GM    = THE PRODUCT OF G, THE GAUSSIAN CONSTANT SQUARED,     00144310
                     C                    AND M, THE MASS OF THE EARTH                         00144320
                     C                                                                         00144330
                     C            UNITS OF INPUT ARGUMENTS X, VX, AND GM ARE ARBITRARY BUT     00144340
                     C            MUST BE MUTUALLY CONSISTENT.                                 00144350
                     C            INPUT ARGUMENTS MUST BE AVAILABLE IN CALLING PROGRAM IN      00144360
                     C            DOUBLE PRECISION FORM.                                       00144370
                     C                                                                         00144380
                     C      OUTPUT                                                             00144390
                     C            A(1) = SEMI-MAJOR AXIS                                       00144400
                     C            A(2) = ECCENTRICITY                    - DIMENSIONLESS       00144410
                     C            A(3) = INCLINATION                     - RADIANS             00144420
                     C            A(4) = RIGHT ASCENSION OF ASCENDING NODE - RADIANS           00144430
                     C            A(5) = ARGUMENT OF PERIGEE             - RADIANS             00144440
                     C            A(6) = MEAN ANOMALY                    - RADIANS             00144450
                     C                                                                         00144460
                     C            P     = ANOMALISTIC PERIOD                                   00144470
                     C            EN    = MEAN ANGULAR MOTION                                  00144480
                     C                                                                         00144490
                     C            UNITS OF OUTPUT ARGUMENTS A(1), P, AND EN WILL DEPEND UPON   00144500
                     C            THE UNITS EMPLOYED FOR X, VX, AND GM.                        00144510
                     C            ALL ANGLES ARE IN RADIANS.                                   00144520
                     C            OUTPUT ARGUMENTS ARE RETURNED TO CALLING PROGRAM IN DOUBLE   00144530
ISN 0004           100 CONTINUE                                                                00144540
                     C            FORM.                                                        00144550
                     C                                                                         00144560
                     C                                                                         00144570
                     C      REFERENCE                                                          00144580
                     C            REFER TO MATHEMATICAL DESCRIPTION IN SUBPROGRAM WRITEUP      00144590
```

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C                                                                       00144600
C     METHOD                                                            00144610
C           REFER TO MATHEMATICAL DESCRIPTION IN SUBPROGRAM WRITEUP     00144620
C                                                                       00144630
C     RESTRICTIONS                                                      00144640
C           ECCENTRICITY MUST BE LESS THAN 1.0.                         00144650
C                                                                       00144660
C     ACCURACY                                                          00144670
C           REFER TO ACCURACY TESTS IN SUBPROGRAM WRITEUP.              00144680
C           INTERNAL ARITHMETIC IS PERFORMED IN DOUBLE PRECISION.       00144690
C                                                                       00144700
C     REQUIRED SUBPROGRAMS                                              00144710
C           07/22/63  ALLOT                                             00144720
C           07/22/63  ATANZ                                             00144730
C                                                                       00144740
C                                                                       00144750
C     TIMING                                                            00144760
C           NO ESTIMATE AVAILABLE                                       00144770
C                                                                       00144780
C                                                                       00144790
C                                                                       00144800
C***** START PROGRAM ***************************************************00144810
C                                                                       00144820
ISN 0005        DIMENSION X(3),VX(3),A(6),Y(3),VY(3)                    00144830
C                                                                       00144840
ISN 0006      500 DO 502 N=1,3                                          00144850
ISN 0007      501 Y(N)=X(N)                                             00144860
ISN 0008      502 VY(N)=VX(N)                                           00144870
ISN 0009          R2=Y(1)**2+Y(2)**2+Y(3)**2                          00144880
ISN 0010        3 R=DSQRT(R2)                                         00144890
ISN 0011        4 V2=VY(1)**2+VY(2)**2+VY(3)**2                       00144900
ISN 0012        5 V=DSQRT(V2)                                         00144910
ISN 0013        6 RDOT=Y(1)*VY(1)+Y(2)*VY(2)+Y(3)*VY(3)               00144920
ISN 0014        7 H1=Y(2)*VY(3)-Y(3)*VY(2)                            00144930
ISN 0015        8 H2=Y(3)*VY(1)-Y(1)*VY(3)                            00144940
ISN 0016        9 H3=Y(1)*VY(2)-Y(2)*VY(1)                            00144950
ISN 0017       10 C2=H1**2+H2**2                                      00144960
ISN 0018       11 C1=DSQRT(C2)                                        00144970
ISN 0019       12 H=DSQRT(H3**2+C2)                                   00144980
ISN 0020       13 RC1=R*C1                                            00144990
ISN 0021       14 RTGM=DSQRT(GM)                                      00145000
ISN 0022       15 A(1)=GM*R/(GM+GM-R*V2)                              00145010
ISN 0023       16 RTA=DSQRT(A(1))                                     00145020
ISN 0024       17 F1=RDOT/(RTGM*RTA)                                  00145030
ISN 0025       18 AR=A(1)/R                                           00145040
ISN 0026       19 F2=1.D00-R/A(1)                                     00145050
ISN 0027          E2=F1**2+F2**2                                      00145060
ISN 0028       21 A(2)=DSQRT(E2)                                      00145070
ISN 0029       22 SI=C1/H                                             00145080
ISN 0030       23 CI=H3/H                                             00145090
ISN 0031       24 SN=H1/C1                                            00145100
ISN 0032       25 CN=-H2/C1                                           00145110
ISN 0033       26 SU=H*Y(3)/RC1                                       00145120
ISN 0034       27 CU=(Y(2)*H1-Y(1)*H2)/RC1                            00145130
ISN 0035       28 SE=F1/A(2)                                          00145140
ISN 0036       29 CE=F2/A(2)                                          00145150
```

```
ISN 0037            SF=AR*SL*DSQRT(1.CD0-E2)                                00145160
ISN 0038            CF=AR*(CE-A(2))                                         00145170
ISN 0039         30 A(3)=ATANZ(SI,CI)                                       00145180
ISN 0040         31 A(4)=ATANZ(SN,CN)                                       00145190
ISN 0041         32 U=ATANZ(SU,CU)                                          00145200
ISN 0042            F=ATANZ(SF,CF)                                          00145210
ISN 0043         33 E=ATANZ(SE,CE)                                          00145220
ISN 0044            A5=U-F                                                  00145230
ISN 0045            A(5)=ALLOT (A5)                                         00145240
ISN 0046         34 A6=E-A(2)*SE                                            00145250
ISN 0047         35 A(6)= ALLOT (A6)                                        00145260
ISN 0048         36 EN=RTGM/(RTA*A(1))                                      00145270
ISN 0049         37 P=6.28318530717959ED0/EN                                00145280
ISN 0050            RETURN                                                  00145290
ISN 0051            END                                                     00145300
```

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS																
A	0002	0005	0022	0023	0025	0026	0028	0035	0036	0038	0039	0040	0045	0046	0047	0048	
E	0043	0046															
F	0042	0044															
H	0019	0029	0030	0033													
N	0006	0007	0007	0008	0008												
P	0002	0049															
R	0010	0020	0022	0022	0025	0026											
U	0041	0044															
X	0002	0005	0007														
Y	0005	0007	0009	0009	0009	0013	0013	0013	0014	0014	0015	0015	0016	0016	0033	0034	0034
AR	0025	0037	0038														
A5	0044	0045															
A6	0046	0047															
CE	0036	0038	0043														
CF	0038	0042															
CI	0030	0039															
CN	0032	0040															
CU	0034	0041															
C1	0018	0020	0029	0031	0032												
C2	0017	0018	0019														
EN	0002	0048	0049														
E2	0027	0028	0037														
F1	0024	0027	0035														
F2	0026	0027	0036														
GM	0002	0021	0022	0022	0022												
H1	0014	0017	0031	0034													
H2	0015	0017	0032	0034													
H3	0016	0019	0030														
R2	0009	0010															
SE	0035	0037	0043	0046													
SF	0037	0042															
SI	0029	0039															
SN	0031	0040															
SU	0033	0041															
VX	0002	0005	0008														
VY	0005	0008	0011	0011	0011	0013	0013	0013	0014	0014	0015	0015	0016	0016			
V1	0012																
V2	0011	0012	0022														
RC1	0020	0033	0034														
ATA	0023	0024	0048														
ATGM	0021	0024	0048														
ALLOT	0045	0047															
ATANZ	0039	0040	0041	0042	0043												
DSQRT	0010	0012	0018	0019	0021	0023	0028	0037									
RALOT	0013	0024															
AVELZ	0002																

*****F O R T R A N C R O S S R E F E R E N C E L I S T I N G*****

LABEL	DEFINED	REFERENCES
3	0010	
4	0011	
5	0012	
6	0013	
7	0014	
8	0015	
9	0016	
10	0017	
11	0018	
12	0019	
13	0020	
14	0021	
15	0022	
16	0023	
17	0024	
18	0025	
19	0026	
21	0028	
22	0029	
23	0030	
24	0031	
25	0032	
26	0033	
27	0034	
28	0035	
29	0036	
30	0039	
31	0040	
32	0041	
33	0043	
34	0046	
35	0047	
36	0048	
37	0049	
100	0004	
500	0006	
501	0007	
502	0008	0006

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LEVEL 16 ( 1 JULY 68)                    OS/360  FORTRAN H                    DATE  69.212/13.36.14

          COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
              CSUBROUTINE SSWTCH                                                    0014E460
   ISN 0002           SUBROUTINE SSWTCH(N1,NSW)                                   0014E470
              C                                                                     0014E480
              C                                                                     0014E490
              C                                                                     0014E500
   ISN 0003           IMPLICIT REAL*8(A-H,O-Z)                                    0014E510
   ISN 0004           DIMENSION NSET(6)                                           0014E520
   ISN 0005           IF(N1.GT.6)GO TO 50                                         0014E530
   ISN 0007           NSW=NSET(N1)                                                0014E540
   ISN 0008           GO TO 100                                                   0014E550
   ISN 0009        50 NSET(N1-6)=NSW                                              0014E560
   ISN 0010           IF(NSET(N1-6).EQ.0)NSET(N1-6)=2                             0014E570
   ISN 0012       100 RETURN                                                      0014E580
   ISN 0013           END                                                         0014E590
```

*****F O R T R A N C R O S S R E F E R E N C E L I S T I N G*****

SYMBOL	INTERNAL STATEMENT NUMBERS					
N1	0002	0005	0007	0009	0010	0010
NSW	0002	0007	0009			
NSET	0004	0007	0009	0010	0010	
SSWTCH	0002					

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
50	0009	0005
100	0012	0008

```
        COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
             SUBROUTINE SUPPO                                                                  00146700
ISN 0002             SUBROUTINE SUPPO                                                          00146710
ISN 0003             IMPLICIT REAL*8(A-H,O-Z,$)                                                00146720
ISN 0004             COMMON DUM1,A110,GP,ERR8,XX,AB,RXB,VXB,XXX,SS,EL,DUM2,DUMF,               00146730
                    1CONV,AIDH,AG,D1,D2,D3 ,CMU,T0,DJ0,DTIMES,ARG0,ARGMOT,ARG,CCOEF,           00146740
                    2SCOEF,DSUP,CJ2S,CJ3,CJ4,DLJ2S,DLJ3,DLJ4,DLSUM,DAJ2S,DAJ3,DAJ4,            00146750
                    3EASUM,REM , ASHORT   ,                                                    00146760
                    4           NBRWR1,NLONG,NSHORT,NSEC,NSECD,NSUPP,NSUPPD,NARG,KCOUNT        00146770
                    5,NKOZ,NKOZD                                                               00146780
ISN 0005             DIMENSION DUM1(100),A110(6),GP(5),XX(12),AB(6),RXB(3),VXB(3),             00146790
                    1XXX(10),SS(3),EL(13),DUM2(85),DUMF(9),AIDH(24),AG(6),D1(6),D2(6),        00146800
                    2D3(6),T0(99),ARG0(99),ARGMOT(99),ARG(99),CCOEF(99,6),SCOEF(99,6) ,       00146810
                    3DSUP(6)  ,ASHORT(6)                                                       00146820
ISN 0006            1 FORMAT(I6)                                                               00146830
ISN 0007            2 FORMAT(D24.17,F10.6,F14.8/G14.10,G12.9 ,G13.8 ,3G11.6/                   00146840
                     1G14.10,G12.9 ,G13.8 ,3G11.6)                                             00146850
ISN 0008            3 FORMAT(62X,9HARGUMENTS/39X,53HEPOCH,VALUES IN DEGREES AT EPOCH,AND       00146860
                     1 MOTIONS PER HOUR///)                                                    00146870
ISN 0009            4 FORMAT(34X,I3,5X,D24.17,5X,F10.6,3X,F14.8)                               00146880
ISN 0010            5 FORMAT(56X,19HCOSINE COEFFICIENTS//)                                     00146890
ISN 0011            6 FORMAT(58X,17HSINE COEFFICIENTS//)                                       00146900
ISN 0012            7 FORMAT(1H1,52X,27HSUPPLEMENTARY PERTURBATIONS////)                       00146910
ISN 0013            8 FORMAT(18X,                                                              00146920
                     1           I3,5X,F14.10,3X,F12.9 ,3X,F13.8 ,3X,3(F11.6,3X))          00146930
ISN 0014            9 FORMAT(72X)                                                              00146940
                    C     CARDS 8I-8J SUPPLEMENTARY PERTURBATIONS INFORMATION CARDS.           00146950
                    C           NOTE;THESE CARDS ARE REQUIRED IF AND ONLY IF COLUMNS 34-36   00146960
                    C                OF CARD NO. 2(THE RUN CONTROL CARD) CONTAIN A QUANTI-   00146970
                    C               TY OTHER THAN 0.                                         00146980
                    C   CARD 8I                                                              00146990
                    C         MAXIMUM NUMBER OF ARGUMENTS IS 99.                             00147000
                    C       COLUMNS 1-6  NUMBER OF ARGUMENTS OCCURRING IN SUPPLEMENTARY      00147010
                    C                    PERTURBATIONS.                                      00147020
                    C                                                                        00147030
                    C                    EACH ARGUMENT REQUIRES 3 ADDITIONAL CARDS.  THESE   00147040
                    C                    3 ADDITIONAL CARDS ARE 8J1,8J2,8J3.                 00147050
                    C                                                                        00147060
                    C                                                                        00147070
                    C     CARD 8J1                                                           00147080
                    C       COLUMNS  1-24 JULIAN DAY OF EPOCH OF ARGUMENT                    00147090
                    C       COLUMNS 25-34 VALUE OF ARGUMENT AT EPOCH IN DEGREES              00147100
                    C       COLUMNS 35-48 MOTION OF ARGUMENT IN DEGREES PER HOUR             00147110
                    C                     FORMAT IS D24.17,F10.6,F14.8.                      00147120
                    C                                                                        00147130
                    C     CARD 8J2                                                           00147140
                    C       COLUMNS  1-12  COEFFICIENT OF COSINE OF ARGUMENT IN A(MEGA-      00147150
                    C                                                    METERS)             00147160
                    C       COLUMNS 13-24  COEFFICIENT OF COSINE OF ARGUMENT IN E            00147170
                    C       COLUMNS 25-36  COEFFICIENT OF COSINE OF ARGUMENT IN I(DEGREES)   00147180
                    C       COLUMNS 37-47  COEFFICIENT OF COSINE OF ARGUMENT IN NODE(DE-     00147190
                    C                                                      GREES)            00147200
                    C       COLUMNS 48-58  COEFFICIENT OF COSINE OF ARGUMENT IN OMEGA        00147210
                    C                                                     (DEGREES)          00147220
                    C       COLUMNS 59-69  COEFFICIENT OF COSINE OF ARGUMENT IN M(DEGREES)   00147230
```

```
C            FORMAT IS F14.10,F12.9,F13.8,3F11.6                              00147240
C                                                                             00147250
C       CARD 8J3                                                              00147260
C         COLUMNS    1-12  COEFFICIENT OF SINE OF ARGUMENT IN A(MEGA-        00147270
C                                                              METERS)        00147280
C         COLUMNS   13-24  COEFFICIENT OF SINE OF ARGUMENT IN E               00147290
C          COLUMNS 25-36  COEFFICIENT OF SINE OF ARGUMENT IN I(DEGREES)       00147300
C          COLUMNS 37-47  COEFFICIENT OF SINE OF ARGUMENT IN NODE(DE-         00147310
C                                                            GREES)           00147320
C          COLUMNS 48-58  COEFFICIENT OF SINE OF ARGUMENT IN OMEGA(DE-        00147330
C                                                            GREES)           00147340
C          COLUMNS 59-69  COEFFICIENT OF SINE OF ARGUMENT IN M(DEGREES)       00147350
C            FORMAT IS F14.10,F12.9,F13.8,3F11.6                              00147360
C                                                                             00147370
ISN 0015        READ(5,1)NARG                                                 00147380
ISN 0016        DO 1001 I=1,NARG                                              00147390
ISN 0017   1001 READ(5,2)T0(I),ARG0(I),ARGMOT(I),(CCOEF(I,J),J=1,6),          00147400
               1(SCOEF(I,J),J=1,6)                                            00147410
ISN 0018        WRITE(6,7)                                                    00147420
ISN 0019        WRITE(6,3)                                                    00147430
ISN 0020        DO 1002 I=1,NARG                                              00147440
ISN 0021        II=I                                                          00147450
ISN 0022   1002 WRITE(6,4) II,T0(I),ARG0(I),ARGMOT(I)                        00147460
ISN 0023        WRITE(6,7)                                                    00147470
ISN 0024        WRITE(6,5)                                                    00147480
ISN 0025        DO 1003 I=1,NARG                                              00147490
ISN 0026        II=I                                                          00147500
ISN 0027   1003 WRITE(6,8)II,(CCOEF(I,J),J=1,6)                              00147510
ISN 0028        WRITE(6,7)                                                    00147520
ISN 0029        WRITE(6,6)                                                    00147530
ISN 0030        DO 1004 I=1,NARG                                              00147540
ISN 0031        II=I                                                          00147550
ISN 0032   1004 WRITE(6,8)II,(SCOEF(I,J),J=1,6)                              00147560
ISN 0033        DO 1005 I=1,NARG                                              00147570
ISN 0034        ARG0(I)=ARG0(I)/CONV                                          00147580
ISN 0035   1005 ARGMOT(I)=ARGMOT(I)/CONV                                      00147590
ISN 0036        RETURN                                                        00147600
ISN 0037        END                                                           00147610
```

*****F U R T R A N C R O S S R E F E R E N C E L I S T I N G*****

SYMBOL	INTERNAL STATEMENT NUMBERS																		
I	0016	0017	0017	0017	0017	0017	0020	0021	0022	0022	0022	0025	0026	0027	0030	0031	0032	0033	0034
	0034	0035	0035																
J	0017	0017	0017	0017	0017	0017	0027	0027	0027	0032	0032	0032							
AB	0004	0005																	
AG	0004	0005																	
D1	0004	0005																	
D2	0004	0005																	
D3	0004	0005																	
EL	0004	0005																	
GP	0004	0005																	
II	0021	0022	0026	0027	0031	0032													
SS	0004	0005																	
TO	0004	0005	0017	0022															
XX	0004	0005																	
ARG	0004	0005																	
CJ3	0004																		
CJ4	0004																		
CMU	0004																		
DJ0	0004																		
REM	0004																		
RXB	0004	0005																	
VXB	0004	0005																	
XXX	0004	0005																	
AIDH	0004	0005																	
ARG0	0004	0005	0017	0022	0034	0034													
AIIC	0004	0005																	
CJ25	0004																		
CONV	0004	0034	0035																
DAJ3	0004																		
DAJ4	0004																		
DLJ3	0004																		
DLJ4	0004																		
DSUF	0004	0005																	
DUMF	0004	0005																	
DUM1	0004	0005																	
DUM2	0004	0005																	
ERR8	0004																		
NARG	0004	0015	0016	0020	0025	0030	0033												
NKOZ	0004																		
NSEC	0004																		
SCOEF	0004	0005	0017	0027															
DAJ25	0004																		
DASUM	0004																		
DLJ25	0004																		
DLSUM	0004																		
NKOZD	0004																		
NLONG	0004																		
NSECD	0004																		
NSUPF	0004																		
SCOEF	0004	0005	0017	0032															
SUPPO	0002																		
ARGMOT	0004	0005	0017	0022	0035	0035													
ASHORT	0004	0005																	
ETIMES	0004																		

*****FORTRAN CROSS REFERENCE LISTING*****

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SYMBOL  INTERNAL STATEMENT NUMBERS
KCOUNT  0004
NBRWRI  0004
NSHORT  0004
NSUPPD  0004
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*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
1	0006	0015
2	0007	0017
3	0008	0019
4	0009	0022
5	0010	0024
6	0011	0029
7	0012	0018 0023 0028
8	0013	0027 0032
9	0014	
1001	0017	0016
1002	0022	0020
1003	0027	0025
1004	0032	0030
1005	0035	0033

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         COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
             SUBROUTINE SUPP1                                                                    00147620
ISN 0002           SUBROUTINE SUPP1                                                              00147630
ISN 0003           IMPLICIT REAL*8(A-H,O-Z,$)                                                    00147640
ISN 0004           COMMON DUM1,A110,GP,ERRB,XX,AB,PXB,VXB,XXX,SS,EL,DUM2,DUMF,                   00147650
                  1CONV,AIDH,AG,D1,D2,D3 ,CMU,T0,DJ0,DTIMES,ARG0,ARGMOT,ARG,CCOEF,               00147660
                  2SCOEF,DSUP,DJ2S,DJ3,DJ4,DLJ2S,DLJ3,DLJ4,DLSUM,DAJ2S,DAJ3,DAJ4,                00147670
                  3DASUM,REM , ASHORT   ,                                                       00147680
                  4          NBRWR1,NLONG,NSHORT,NSEC,NSECD,NSUPP,NSUPPD,NARG,KCOUNT            00147690
                  5,NKOZ,NKOZD                                                                  00147700
ISN 0005           DIMENSION DUM1(100),A110(6),GP(5),XX(12),AB(6),PXB(3),VXB(3),                 00147710
                  1XXX(10),SS(3),EL(13),DUM2(85),DUMF(9),AIDH(24),AG(6),D1(6),D2(6),            00147720
                  2D3(6),T0(99),ARG0(99),ARGMOT(99),ARG(99),CCOEF(99,6),SCOEF(99,6) ,           00147730
                  3DSUP(6) ,ASHORT(6)                                                           00147740
ISN 0006          1 FORMAT(1X,I3,5X,F10.6,3X,F14.10,3X,F12.9,3X,F13.8,3X,3(F11.6,3X))           00147750
ISN 0007       1853 FORMAT( 1X,79HVALUES OF ARGUMENTS AND CUMULATIVE CONTRIBUTIONS TO           00147760
                  1SUPPLEMENTARY PERTURBATIONS)                                                 00147770
ISN 0008           DO 1010 J=1,6                                                                 00147780
ISN 0009       1010 DSUP(J)=0.D 00                                                               00147790
ISN 0010           IF(KCOUNT)1012,1011,1012                                                      00147800
ISN 0011       1011 WRITE(6,1853)                                                                00147810
ISN 0012       1012 DO 1090 I=1,NARG                                                             00147820
ISN 0013           II=I                                                                          00147830
ISN 0014           TAU = DTIMES/3.6D 03+(DJ0-T0(I))*24.D 00                                      00147840
ISN 0015           ARG(I)=ARG0(I)+TAU*ARGMOT(I)                                                  00147850
ISN 0016           ARGMT=ARG(I)                                                                  00147860
ISN 0017           ARG(I)=ALLOT (ARGMT)                                                          00147870
ISN 0018           ARGUM = ARG(I)*CONV                                                           00147880
ISN 0019           DO 1088 J=1,6                                                                 00147890
ISN 0020       1088 DSUP(J)=DSUP(J)+CCOEF(I,J)*DCOS(ARG(I))+SCOEF(I,J)*DSIN(ARG(I))              00147900
ISN 0021           IF(KCOUNT)1090,1087,1090                                                      00147910
ISN 0022       1087 IF(NSUPPD)1089,1090,1089                                                     00147920
ISN 0023       1089 WRITE(6,1)II,ARGUM,(DSUP(L),L=1,6)                                           00147930
ISN 0024       1090 CONTINUE                                                                     00147940
ISN 0025       1830 FORMAT(72X)                                                                  00147950
ISN 0026           IF(KCOUNT)1092,1091,1092                                                      00147960
ISN 0027       1091 WRITE(6,1830)                                                                00147970
ISN 0028           WRITE(6,1830)                                                                 00147980
ISN 0029       1092 RETURN                                                                       00147990
ISN 0030           END                                                                           00148000
```

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS
I	0012 0013 0014 0015 0015 0015 0016 0017 0018 0020 0020 0020 0020
J	0008 0009 0019 0020 0020 0020 0020
L	0023 0023 0023
AB	0004 0005
AG	0004 0005
D1	0004 0005
D2	0004 0005
D3	0004 0005
EL	0004 0005
GP	0004 0005
II	0013 0023
SS	0004 0005
TO	0004 0005 0014
XX	0004 0005
ARG	0004 0005 0015 0016 0017 0018 0020 0020
CJ3	0004
CJ4	0004
CMU	0004
DJ0	0004 0014
FEM	0004
RXB	0004 0005
TAU	0014 0015
VXB	0004 0005
XXX	0004 0005
AIDM	0004 0005
ARG0	0004 0005 0015
A110	0004 0005
CJ2S	0004
CONV	0004 0018
DAJ3	0004
DAJ4	0004
DCOS	0020
DLJ3	0004
DLJ4	0004
DSIN	0020
DSUP	0004 0005 0004 0020 0020 0023
DUMF	0004 0005
DUM1	0004 0005
DUM2	0004 0005
ERRB	0004
NARG	0004 0012
NKOZ	0004
NSEC	0004
ALLOT	0017
ARGMT	0016 0017
ARGUM	0018 0023
COSEF	0004 0005 0020
DAJ2S	0004
DASUM	0004
DLJ2S	0004
DLSUM	0004
NKOZD	0004
NLONG	0004
NSECD	0004

*****FORTRAN CROSS REFERENCE LISTING*****

SYMBOL	INTERNAL STATEMENT NUMBERS			
NSUPP	0004			
SCCEF	0004	0005	0020	
SUPP1	0002			
ARGMOT	0004	0005	0015	
ASHORT	0004	0005		
DTIMES	0004	0014		
KCOUNT	0004	0010	0021	0026
NBR#R1	0004			
NSHORT	0004			
NSUPPD	0004	0022		

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES			
1	0006	0023			
1010	0009	0008			
1011	0011	0010			
1012	0012	0010	0010		
1087	0022	0021			
1088	0020	0019			
1089	0023	0022	0022		
1090	0024	0012	0021	0021	0022
1091	0027	0026			
1092	0029	0026	0026		
1830	0025	0027	0028		
1853	0007	0011			

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         COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
               CSUBROUTINE TIMC4                                                                  00148010
   ISN 0002          SUBROUTINE TIMC4(DJ0,TSEP,S,F,DT,KPR,KLAST)                                  00148020
   ISN 0003          IMPLICIT REAL*8(A-H,O-Z,$)                                                   00148030
                     C                                                                            00148040
                     C     VERSION OF 7/22/68                                                     00148050
                     C                                                                            00148060
                     C     READS A CARD FROM CARD READER CONTAINING CALENDAR DATE AND UT2 OF      00148070
                     C     DESIRED START AND END TIMES FOR CALCULATION OF AN EPHEMERIS, AND       00148080
                     C     THE TIME INCREMENT OF THE EPHEMERIS IN SECONDS.  CALCULATES TIME       00148090
                     C     INTERVAL IN SECONDS FROM SOME EPOCH (DJ0,TSEP) TO THE START AND        00148100
                     C     END TIMES.                                                             00148110
                     C     WRITES CALENDAR DATE AND UT2 ON TAPE UNIT A3.                          00148120
                     C                                                                            00148130
                     C     CALLING SEQUENCE                                                       00148140
                     C           CALL TIMC4(DJ0,TSEP,S,F,DT,KPR,KLAST)                            00148150
                     C                                                                            00148160
                     C     INPUT FROM CALLING SEQUENCE                                            00148170
                     C           DJ0 = EPOCH JULIAN DATE AT 0 HOURS UT2.                          00148180
                     C           TSEP = EPOCH UT2 IN SECONDS                                      00148190
                     C                                                                            00148200
                     C     INPUT FROM CARD READER                                                 00148210
                     C           NMS,NDS,NYS = MONTH, DAY, YEAR OF START DATE                     00148220
                     C           NMF,NDF,NYF = MONTH, DAY, AND YEAR OF END DATE                   00148230
                     C                                                                            00148240
                     C           NHS,NMNS,TSS = HOUR, MINUTE, SECOND (UT2) OF START TIME          00148250
                     C           NHF,NMNF,TSF = HOUR, MINUTE, SECOND (UT2) OF END DATE            00148260
                     C           DT = TIME INCREMENT OF EPHEMERIS IN SECONDS                      00148270
                     C           KLAST = INDICATION WHETHER ANOTHER EPHEMERIS IS TO BE            00148280
                     C                   PRINTED OR NOT                                           00148290
                     C           KPR   = FREQUENCY OF PRINTING.                                   00148300
                     C                                                                            00148310
                     C     OUTPUT                                                                 00148320
                     C           S = TIME IN SECONDS FROM EPOCH TO START TIME                     00148330
                     C           F = TIME IN SECONDS FROM EPOCH TO END TIME                       00148340
                     C           DT = TIME INCREMENT OF EPHEMERIS IN SECONDS                      00148350
                     C                                                                            00148360
                     C     REQUIRED SUBPROGRAMS                                                   00148370
                     C                                                                            00148380
                     C     DJUL                                                                   00148390
                     C                                                                            00148400
   ISN 0004           6015 FORMAT (2(1X12) ,1X,I4,2I3,F7.3,I3,1X,I2,1X,I4,2I3,F7.3,F11.3,I6,     00148410
                         1I7)                                                                     00148420
   ISN 0005           6016 FORMAT (1X12,1H/12,1H/14,7X11H START DATE/1X12,I3,F7.3,5X,             00148430
                         1 15H START TIME-ET /1XF12.3,5X23H TIME INCREMENT-SECONDS//1X12,        00148440
                         2 1H/12,1H/14,7X9H END DATE/1X12,I3,F7.3,5X13H END TIME-ET ///)         00148450
   ISN 0006           6017 FORMAT(44X,43HDATA FOR EVERY DATE ARE PRINTED ON SYSOUT=A///)         00148460
   ISN 0007           6018 FORMAT(38X,14HDATA FOR EVERY,3X,I6,3X,31HTH DATE ARE PRINTED ON SY00148470
                         1SOUT=A///)                                                              00148480
   ISN 0008           6019 FORMAT(///41X,50H  ANOTHER  EPHEMERIS IS COMPUTED AFTER CURRENT ONC00148490
                         1E///)                                                                   00148500
   ISN 0009           6020 FORMAT(///41X,50H        NO  EPHEMERIS IS COMPUTED AFTER CURRENT ONC00148510
                         1E///)                                                                   00148520
   ISN 0010           6021 FORMAT(38X,14HDATA FOR EVERY,3X,I6,3X,31HND DATE ARE PRINTED ON SY00148530
                         1SOUT=A///)                                                              00148540
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ISN 0011      6022 FORMAT(38X,14HDATA FOR EVERY,3X,I6,3X,31HRD DATE ARE PRINTED ON SYC0148550
                 1SOUT=A///)                                                        00148560
              C   CARD NO. 9 EPHEMERIS REQUEST CARD (ONE EMPHEMERIS REQUEST CARD IS   00148570
              C             REQUIRED FOR EACH EPHEMERIS TO BE COMPUTED)              C0148580
              C         COLUMN    1     BLANK                                      00148590
              C         COLUMNS   2- 3 MONTH OF START TIME                         00148600
              C         COLUMN    4     BLANK                                      00148610
              C         COLUMNS   5- 6 DAY OF START TIME                           00148620
              C         COLUMN    7     BLANK                                      00148630
              C         COLUMNS   8-11 YEAR OF START TIME                          C0148640
              C         COLUMN   12     BLANK                                      00148650
              C         COLUMNS  13-14 HOUR OF START TIME                          00148660
              C         COLUMN   15     BLANK                                      00148670
              C         COLUMNS  16-17 MINUTES OF START TIME                       C0148680
              C         COLUMN   18     BLANK                                      00148690
              C         COLUMNS  19-24 SECONDS OF START TIME TO THOUSANDTHS         00148700
              C                        DECIMAL POINT IN COLUMN 21                  00148710
              C         COLUMN   25     BLANK                                      C0148720
              C         COLUMNS  26-27 MONTH OF END TIME                           00148730
              C         COLUMN   28     BLANK                                      C0148740
              C         COLUMNS  29-30 DAY OF END TIME                             00148750
              C         COLUMN   31     BLANK                                      00148760
              C         COLUMNS  32-35 YEAR OF END TIME                            C0148770
              C         COLUMN   36     BLANK                                      C0148780
              C         COLUMNS  37-38 HOUR OF END TIME                            C0148790
              C         COLUMN   39     BLANK                                      00148800
              C         COLUMNS  40-41 MINUTES OF END TIME                         C0148810
              C         COLUMN   42     BLANK                                      C0148820
              C         COLUMNS  43-48 SECONDS OF END TIME TO THOUSANDTHS          C0148830
              C                        DECIMAL POINT IN COLUMN 45                  C0148840
              C         COLUMNS  49-59 INCREMENT OF TIME IN SECONDS AND THOUSANDTHS OF C0148850
              C                        SECONDS. (DECIMAL POINT IN COLUMN 56)       C0148860
              C         COLUMNS  60-65 FREQUENCY OF DATA IN EPHEMERIS INDICATOR     C0148870
              C                  0 OR A NEGATIVE INTEGER = DATA FOR EVERY DATE WILL C0148880
              C                                            BE PRINTED.            C0148890
              C                  A POSITIVE INTEGER GREATER THAN 1(CALL THIS INTEGERC0148900
              C                  KPR) = DATA FOR EVERY KPR'TH DATE WILL BE PRINTED. 00148910
              C         COLUMNS  66-72 EPHEMERIS REQUEST SENTINEL.                 C0148920
              C                  0= THIS IS THE FINAL EPHEMERIS REQUEST             C0148930
              C                  OTHER THAN ZERO = THIS IS NOT THE FINAL EPHEMERIS  C0148940
              C                                    REQUEST.                         C0148950
ISN 0012        READ               6015,NMS,NDS,NYS,NHS,NMNS,TSS,NMF,NDF,NYF,NHF,  C0148960
                1 NMNF,TSF,DT,KPR,KLAST                                             C0148970
ISN 0013        1 PRINT 6016,NMS,NDS,NYS,NHS,NMNS,TSS,DT,NMF,NDF,NYF,NHF,NMNF,TSF   C0148980
ISN 0014          IF(KPR-1)3,3,30                                                   00148990
ISN 0015        3 WRITE(6,6017)                                                     00149000
ISN 0016          GO TO 5                                                           C0149010
ISN 0017       30 IF(KPR-2)31,31,3                                                  00149020
ISN 0018       31 WRITE(6,6021)KPR                                                  00149030
ISN 0019          GO TO 5                                                           00149040
ISN 0020       32 IF(KPR-3)33,33,4                                                  C0149050
ISN 0021       33 WRITE(6,6022)KPR                                                  00149060
ISN 0022          GO TO 5                                                           00149070
ISN 0023        4 WRITE(6,6018)KPR                                                  00149080
ISN 0024        5 IF(KLAST)7,6,7                                                    00149090
ISN 0025        6 WRITE(6,6020)                                                     00149100
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ISN 0026            GO TO 2                                                  00149110
ISN 0027          7 WRITE(6,6019)                                            00149120
ISN 0028          2 DJS0=DJUL(NMS,NDS,NYS)                                   00149130
ISN 0029            DJF0=DJUL(NMF,NDF,NYF)                                   00149140
ISN 0030            THS=NHS*3600                                             00149150
ISN 0031            TMNS=NMNS*60                                             00149160
ISN 0032            TS=THS+TMNS+TSS-TSEP                                     00149170
ISN 0033            THF=NHF*3600                                             00149180
ISN 0034            TMNF=NMNF*60                                             00149190
ISN 0035            TF=THF+TMNF+TSF-TSEP                                     00149200
ISN 0036            DJS=DJS0-DJ0                                             00149210
ISN 0037            DJF=DJF0-DJ0                                             00149220
ISN 0038            S=DJS*86400.D0+TS                                        00149230
ISN 0039            F=DJF*86400.D0+TF                                        00149240
ISN 0040            RETURN                                                   00149250
ISN 0041            END                                                      00149260
```

****FORTRAN CROSS REFERENCE LISTING****

SYMBOL	INTERNAL STATEMENT NUMBERS							
F	0002	0039						
$	0002	0038						
DT	0002	0012	0013					
TF	0035	0039						
TS	0032	0038						
DJF	0037	0039						
DJS	0036	0038						
DJ0	0002	0036	0037					
KPR	0002	0012	0014	0017	0018	0020	0021	0023
NDF	0012	0013	0029					
NDS	0012	0013	0028					
NHF	0012	0013	0033					
NHS	0012	0013	0030					
NMF	0012	0013	0029					
NMS	0012	0013	0028					
NYF	0012	0013	0029					
NYS	0012	0013	0028					
THF	0033	0035						
THS	0030	0032						
TSF	0012	0013	0035					
TSS	0012	0013	0032					
DJF0	0029	0037						
DJS0	0028	0036						
DJUL	0028	0029						
NMNF	0012	0013	0034					
NMNS	0012	0013	0031					
TMNF	0034	0035						
TMNS	0031	0032						
TSEP	0002	0032	0035					
KLAST	0002	0012	0024					
TIMC4	0002							

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
1	0013	
2	0028	0026
3	0015	0014 0014
4	0023	0020
5	0024	0016 0019 0022
6	0025	0024
7	0027	0024 0024
30	0017	0014
31	0018	0017 0017
32	0020	0017
33	0021	0020 0020
6015	0004	0012
6016	0005	0013
6017	0006	0015
6018	0007	0023
6019	0008	0027
6020	0009	0025
6021	0010	0018
6022	0011	0021

```
          COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
              CSUBROUTINE WRT6                                                                    00151560
   ISN 0002           SUBROUTINE WRT6(M,COORD,VELOC,ACC,ELMT,N1  ,N2  ,N3  ,L1,L2,L3)            00151570
   ISN 0003           IMPLICIT REAL*8(A-H,O-Z,$)                                                  00151580
   ISN 0004           DIMENSION COORD(3),VELOC(3),ACC(3),ELMT(6)                                  00151590
   ISN 0005     22522 FORMAT(1X,I5,6D21.14)                                                       00151600
   ISN 0006     22529 FORMAT(1X,I5,3D23.16,57X)                                                   00151610
   ISN 0007           IF(L1)100,101,100                                                           00151620
   ISN 0008       100 WRITE(N1,22522)   M,(COORD(I),I=1,3),(VELOC(I),I=1,3)                     00151630
   ISN 0009           WRITE(N1,22529)   M,(ACC(I),I=1,3)                                        00151640
   ISN 0010           WRITE(N1,22522)   M,(ELMT(I),I=1,6)                                       00151650
   ISN 0011       101 IF(L2)102,103,102                                                         00151660
   ISN 0012       102 WRITE(N2,22522)   M,(COORD(I),I=1,3),(VELOC(I),I=1,3)                     00151670
   ISN 0013           WRITE(N2,22529)   M,(ACC(I),I=1,3)                                        00151680
   ISN 0014           WRITE(N2,22522)   M,(ELMT(I),I=1,6)                                       00151690
   ISN 0015       103 IF(L3)104,105,104                                                         00151700
   ISN 0016       104 WRITE(N3,22522)   M,(COORD(I),I=1,3),(VELOC(I),I=1,3)                     00151710
   ISN 0017           WRITE(N3,22529)   M,(ACC(I),I=1,3)                                        00151720
   ISN 0018           WRITE(N3,22522)   M,(ELMT(I),I=1,6)                                       00151730
   ISN 0019       105 RETURN                                                                    00151740
   ISN 0020           END                                                                         00151750
```

SYMBOL	INTERNAL STATEMENT NUMBERS																		
I	0008	0008	0008	0008	0008	0008	0009	0009	0009	0010	0010	0010	0012	0012	0012	0012	0012	0012	0013
	0013	0013	0014	0014	0014	0016	0016	0016	0016	0016	0016	0017	0017	0017	0018	0018	0018		
M	0002	0008	0009	0010	0012	0013	0014	0016	0017	0018									
L1	0002	0007																	
L2	0002	0011																	
L3	0002	0015																	
N1	0002	0008	0009	0010															
N2	0002	0012	0013	0014															
N3	0002	0016	0017	0018															
ACC	0002	0004	0009	0013	0017														
ELMT	0002	0004	0010	0014	0018														
WRT6	0002																		
COORD	0002	0004	0008	0012	0016														
VELOC	0002	0004	0008	0012	0016														

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
100	0008	0007 0007
101	0011	0007
102	0012	0011 0011
103	0015	0011
104	0016	0015 0015
105	0019	0015
22522	0005	0008 0010 0012 0014 0016 0018
22529	0006	0009 0013 0017

```
          COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
               SUBROUTINE XKEP                                                                    00152640
   ISN 0002            REAL FUNCTION XKEP *8(AM,ECC,SE,CE,ERR,G,NMAX,N)                          00152650
   ISN 0003            IMPLICIT REAL*8(A-H,O-Z,$)                                                00152660
                  C                                                                              00152670
                  C     NAME CHANGED 11/12/68 FROM XKEPZ TO XKEP                                 00152680
                  C                                                                              00152690
                  C     PURPOSE                                                                  00152700
                  C           SOLVES KEPLER'S EQUATION.                                          00152710
                  C                                                                              00152720
                  C                 INPUT                                                        00152730
                  C           AM    =   MEAN ANOMALY                              - RADIANS -    00152740
                  C           ECC   =   ECCENTRICITY                                           00152750
                  C           ERR   =   TOLERANCE FOR (E2-E1)/E2 IN SOLVING KEPLER'S           00152760
                  C                     EQLATION.                                              00152770
                  C           NMAX  =   MAXIMUM NUMBER OF ITERATIONS ALLOWED                   00152780
                  C                     IN SOLVING KEPLER'S EQUATION.                          00152790
                  C                                                                              00152800
                  C                 OUTPUT                                                       00152810
                  C           SE    =     SINE OF ECCENTRIC ANOMALY                            00152820
                  C           CE    =   COSINE OF ECCENTRIC ANOMALY                            00152830
                  C           G     =   LAST CORRECTION (E2-E1)/E2                             00152840
                  C                     IN SOLVING KEPLER'S EQUATION.                          00152850
                  C           N     =   SERIAL NUMBER OF CURRENT ITERATION IN SOLVING          00152860
                  C                     KEPLER'S EQUATION.                                     00152870
                  C                                                                              00152880
                  C     REQUIRED SUBPROGRAMS                                                     00152890
                  C           NONE                                                               00152900
                  C                                                                              00152910
   ISN 0004         7 E1 = AM + (ECC * DSIN(AM)   )                                             00152920
   ISN 0005           N = 0                                                                       00152930
   ISN 0006         1 E2 = E1                                                                     00152940
   ISN 0007           N = N + 1                                                                   00152950
   ISN 0008           SE =  DSIN(E1)                                                              00152960
   ISN 0009           CE =  DCOS(E1)                                                              00152970
   ISN 0010           E1 = E1 + ((AM - E1 + ECC*SE) / (1.0D0 - ECC*CE))                           00152980
   ISN 0011           IF(E1.EQ.0.D0) GO TO 8                                                      00152990
   ISN 0013           G = DABS((E1 - E2) / E1)                                                    00153000
   ISN 0014           GO TO 9                                                                     00153010
   ISN 0015         8 G=0.0D0                                                                     00153020
   ISN 0016         9 IF(N-NMAX)2,2,3                                                             00153030
   ISN 0017         2 IF(G - ERR    ) 5,5,1                                                       00153040
   ISN 0018         3 PRINT 4                                                                     00153050
   ISN 0019           PRINT 6,AM,E1,E2,G,N                                                        00153060
   ISN 0020         4 FORMAT (36H0NO CONVERGENCE IN KEPLERS EQUATION           )                00153070
   ISN 0021         6 FORMAT (4D16.8,I5)                                                          00153080
   ISN 0022           CALL SLITE(2)                                                               00153090
   ISN 0023         5 XKEP  = E1                                                                  00153100
   ISN 0024           RETURN                                                                      00153110
   ISN 0025           END                                                                         00153120
```

FORTRAN CROSS REFERENCE LISTING

SYMBOL	INTERNAL STATEMENT NUMBERS												
G	0002	0013	0015	0017	0019								
N	0002	0005	0007	0007	0016	0019							
AM	0002	0004	0004	0010	0019								
CE	0002	0009	0010										
E1	0004	0006	0008	0009	0010	0010	0010	0011	0013	0013	0019	0023	
E2	0006	0013	0019										
SE	0002	0008	0010										
ECC	0002	0004	0010	0010									
ERR	0002	0017											
DABS	0013												
DCOS	0009												
DSIN	0004	0008											
NMAX	0002	0016											
XKEP	0002	0023											
SLITE	0022												

*****FORTRAN CROSS REFERENCE LISTING*****

LABEL	DEFINED	REFERENCES
1	0006	0017
2	0017	0016 0016
3	0018	0016
4	0020	0018
5	0023	0017 0017
6	0021	0019
7	0004	
8	0015	0011
9	0016	0014

APPENDIX B

DESCRIPTION OF INPUT DECK

```
C                        CARD 1
C
C
C
C
C   CARD NO. 1   RUN IDENTIFICATION CARD (CAN CONTAIN ANY DESIRED INFOR-
C                MATION IN COLUMNS 2 THROUGH 72.)
C
```

```
C                        CARD 2
C
C
C
C
C   CARD NO. 2   RUN CONTROL CARD
C     COLUMNS 1-3  INPUT TYPE INDICATOR  (INPUT)
C                  +01 = OSCULATING ELEMENTS
C                  +03 = INERTIAL POSITION AND VELOCITY
C                  +04 = BROUWER MEAN ELEMENTS
C     COLUMNS 4-6  SOURCE OF EARTH CONSTANTS INDICATOR  (NCST)
C                  ANY POSITIVE INTEGER = EARTH CONSTANTS TO BE READ FROM
C                                         CARDS 4 AND 5.
C                  ANY NEGATIVE INTEGER OR ZERO : OMIT CARDS 4 AND 5
C                                                 THE FOLLOWING CONSTANTS
C                                                 ARE USED:
C                                       0 = GODDARD EARTH CONSTANTS ARE
C                                           BEING USED.
C          GM =3.98603200D+05((KM CUBED)/(SECONDS SQUARED))
C          R = 6378.165 KM
C J2=+1.08230D-03    J3=-2.300D-06
C J4=-1.800D-06      J5= 0.0
C                                      -1 = EARTH CONSTANTS OF THE SIRY
C                                           PACKAGE ARE BEING USED.
C          GM =3.98626880D+05((KM CUBED)/(SECONDS SQUARED))
C          R = 6378.388 KM
C J2=+1.08219D-03    J3=-2.285D-06
C J4=-2.123D-06      J5=-2.32D-07
C                                      -2 = GODDARD EARTH CONSTANTS WITH
C                                           HARMONICS = ZERO ARE BEING USED.
C          GM =3.98603200D+05((KM CUBED)/(SECONDS SQUARED))
C          R = 6378.165 KM
C                                      -3 = INTERNATIONAL EARTH CONSTANTS
C                                           WITH HARMONICS = ZERO ARE BEING
C                                           USED.
C          GM =3.98626873D+05((KM CUBED)/(SECONDS SQUARED))
C          R = 6378.388 KM
C     COLUMNS 7-9  INDICATOR OF SOURCE FOR TOLERANCE AND MAXIMUM NUMBER
C                  OF ITERATIONS ALLOWED IN SOLVING KEPLER'S EQUATION
C                  (NERR).
C                  TOLERANCE IS UPPER LIMIT OF (E2-E1)/E2,WHERE E1 AND
C                  E2 ARE VALUES OF THE ECCENTRIC ANOMALY IN TWO SUCCES-
C                  SIVE ITERATIONS.
C                  ANY POSITIVE INTEGER = READ TOLERANCE AND MAXIMUM NUM-
C                                         BER OF ITERATIONS ALLOWED IN SO-
C                                         LUTION OF KEPLER'S EQUATION FROM
C                                         CARD 3.
C                  ANY NEGATIVE INTEGER
C                  OR 0                 = OMIT CARD 3. TOLERANCE FOR EC-
C                                         CENTRIC ANOMALY IS .10D-13 AND
C                                         THE MAXIMUM NUMBER OF ITERATIONS
C                                         IS 50.
```

```
C                        CARD 2 (CONTINUED)
C
C
C
C
C     COLUMNS 10-12  BROUWER TRUNCATION INDICATOR IN SUBROUTINE BBRWR
C                    (NDA).
C     ANY POSITIVE
C     INTEGER      = READ TOLERANCES TO BE USED IN DETERMINING MEAN
C                    BROUWER ELEMENTS FROM CARD 6.
C                ANY NEGATIVE
C                INTEGER OR 0 = OMIT CARD 6. THE FOLLOWING TOLERANCES
C                               ARE USED IN DETERMINING BROUWER MEAN
C                               ELEMENTS.
C                                 SEMIMAJOR AXIS       = .50D-10 KM
C                                 ECCENTRICITY         = .50D-14
C                                 INCLINATION          = .50D-11 DEGREES
C                 RIGHT ASCENSION OF ASCENDING NODE    = .50D-11 DEGREES
C                                 ARGUMENT OF PERIGEE  = .50D-11 DEGREES
C                                 MEAN ANOMALY         = .50D-11 DEGREES
C     COLUMNS 13-15  MAXIMUM NUMBER OF ITERATIONS ALLOWED IN DETERMINING
C                    BROUWER MEAN ELEMENTS(IRC).
C     COLUMNS 16-18  TYPE OF UNITS USED ON CARDS 8A-8H(NUNIT).
C                0 = UNIT  OF LENGTH = MEGAMETERS,UNIT OF TIME = HOUR,
C                    ANGLES IN DEGREES
C                    COEFFICIENTS OF LINEAR TERMS ARE GIVEN PER HOUR
C                    COEFFICIENTS OF QUADRATIC TERMS ARE GIVEN PER
C                    ( 100 HOURS ) SQUARED
C                    COEFFICIENTS OF CUBIC     TERMS ARE GIVEN PER
C                    ( 100 HOURS ) CUBED.
C                OTHER THAN 0 = UNIT OF LENGTH = EARTH'S RADIUS,UNIT OF
C                    TIME = CUT, ANGLES IN RADIANS.
C                    (VANGUARD UNITS)
C                    COEFFICIENTS OF LINEAR TERMS ARE GIVEN PER CUT
C                    COEFFICIENTS OF QUADRATIC TERMS ARE GIVEN PER
C                    ( CUT ) SQUARED.
C                    COEFFICIENTS OF CUBIC     TERMS ARE GIVEN PER
C                    ( CUT ) CUBED.
C     COLUMNS 19-21  INTERMEDIATE OUTPUT FROM SUBROUTINE BRWR1 INDICATOR
C                    (NBRWR1).
C                0 = DO NOT PRINT INTERMEDIATE OUTPUT.
C                OTHER THAN 0 = PRINT INTERMEDIATE OUTPUT.
C     COLUMNS 22-24  LONG PERIOD PERTURBATIONS INDICATOR (NLONG)
C                0 = DO NOT INCLUDE LONG PERIOD PERTURBATIONS
C                OTHER THAN 0 = INCLUDE LONG PERIOD PERTURBATIONS
C     COLUMNS 25-27  SHORT PERIOD PERTURBATIONS INDICATOR (NSHORT)
C                0 = DO NOT INCLUDE SHORT PERIOD PERTURBATIONS
C       ANY NEGATIVE INTEGER = THE SHORT PERIOD PERTURBATIONS ARE COM-
C                              PUTED WITH E" AND I".
C       ANY POSITIVE INTEGER = THE SHORT PERIOD PERTURBATIONS ARE COM-
C                              PUTED WITH E' AND I'.
```

```
C                        CARD 2 (CONTINUED)
C
C
C
C
C      COLUMNS 28-30  SECOND ORDER SHORT-PERIOD TERMS IN SEMIMAJOR AXIS
C                     INDICATOR (NSEC)
C                  0 = DO NOT INCLUDE SECOND ORDER SHORT-PERIOD TERMS.
C                  OTHER THAN 0 = INCLUDE SECOND ORDER SHORT-PERIOD TERMS.
C      COLUMNS 31-33 INTERMEDIATE OUTPUT OF SECOND ORDER SHORT-PERIOD
C                     PERTURBATIONS IN SEMIMAJOR AXIS INDICATOR (NSECD)
C                  0= DO NOT PRINT INTERMEDIATE OUTPUT.
C                  OTHER THAN 0 = PRINT INTERMEDIATE OUTPUT.
C         NOTE:  INTERMEDIATE DATA OUTPUT AT EPOCH WILL NOT BE PRINTED
C              UNLESS EPOCH DATE IS INCLUDED AMONG THE DATES IN REQUESTED
C              EPHEMERIDES
C      COLUMNS 34-36  SUPPLEMENTARY PERTURBATIONS INDICATOR (NSUPP)
C                  0 = DO NOT INCLUDE SUPPLEMENTARY PERTURBATIONS
C                  OTHER THAN 0 = INCLUDE SUPPLEMENTARY PERTURBATIONS.
C      COLUMNS 37-39 !NTERMEDIATE OUTPUT OF SUPPLEMENTARY PERTURBATIONS
C                     INDICATOR (NSUPPD)
C                  0= DO NOT PRINT INTERMEDIATE OUTPUT.
C                  OTHER THAN 0 = PRINT INTERMEDIATE OUTPUT.
C         NOTE:  INTERMEDIATE DATA OUTPUT AT EPOCH WILL NOT BE PRINTED
C              UNLESS EPOCH DATE IS INCLUDED AMONG THE DATES IN REQUESTED
C              EPHEMERIDES
C      COLUMNS 40-42  MEAN MOTION INDICATOR (NKOZ)
C                  0 = USE BROUWER'S MEAN MOTIONS.
C                  OTHER THAN 0 = USE KOZAI'S MEAN MOTIONS.
C      COLUMNS 43-45  INTERMEDIATE OUTPUT OF COMPUTATION OF KOZAI MEAN
C                     MOTIONS INDICATOR (NKOZD)
C                     0 = DO NOT PRINT INTERMEDIATE OUTPUT.
C                     OTHER THAN 0 = PRINT INTERMEDIATE OUTPUT.
```

```
C                       CARD 3
C
C
C
C
C     CARD NO. 3   TOLERANCE AND MAXIMUM NUMBER OF ITERATIONS ALLOWED IN
C                  SOLVING KEPLER'S EQUATION.
C                    TOLERANCE IS UPPER LIMIT OF (E2-E1)/E2,WHERE E1 AND
C                    E2 ARE VALUES OF THE ECCENTRIC ANOMALY IN TWO SUCCES-
C                    SIVE ITERATIONS.
C
C              NOTE: THIS CARD IS REQUIRED IF AND ONLY IF COLUMNS 7-9
C              OF CARD 2(RUN CONTROL CARD) CONTAIN A POSITIVE INTEGER.
C
C       COLUMNS 1- 8 ECCENTRIC ANOMALY TOLERANCE IN FORMAT D8.2.
C       COLUMNS 9-12 MAXIMUM NO OF ITERATIONS ALLOWED IN SOLUTION OF KEP-
C                    LER'S EQUATION.
C
```

```
C                        CARDS 4 AND 5
C
C
C
C
C   CARDS NO. 4 AND 5  EARTH CONSTANTS CARDS
C
C              NOTE: THESE CARDS ARE REQUIRED IF AND ONLY IF COLUMNS 4-6
C                       OF CARD NO. 2 (THE RUN CONTROL CARD) CONTAIN  A
C                       POSITIVE INTEGER.
C
C
C           FOR CARD 4
C      COLUMNS  1-12 CONSTANT OF ATTRACTION IN (KM CUBED / SEC SQUARED)
C      COLUMNS 13-24  J2 )
C      COLUMNS 25-36  J3  ) COEFFICIENTS OF ZONAL HARMONICS
C      COLUMNS 37-48  J4  ) OF DEGREES 2-5
C      COLUMNS 49-60  J5 )
C      FORMAT IS D12.6,4D12.5
C
C           FOR CARD 5
C      COLUMNS 1-24 MEAN EQUATORIAL RADIUS OF THE EARTH IN MEGAMETERS
C                   FORMAT IS D24.17
```

```
C                        CARD 6
C
C
C
C
C   CARD NO. 6  BROUWER MEAN ELEMENTS TOLERANCE CARD
C             NOTE:THIS CARD IS REQUIRED IF AND ONLY IF COLUMNS 10-12
C             OF CARD NO. 2(THE RUN CONTROL CARD) CONTAIN A POSITIVE
C             INTEGER.
C     COLUMNS  1- 8 TOLERANCE FOR SEMIMAJOR AXIS IN MEGAMETERS
C     COLUMNS  9-16 TOLERANCE FOR ECCENTRICITY
C     COLUMNS 17-24 TOLERANCE FOR INCLINATION IN DEGREES
C     COLUMNS 25-32 TOLERANCE FOR RIGHT ASCENSION OF ASCENDING NODE IN
C                                 DEGREES
C     COLUMNS 33-40 TOLERANCE FOR ARGUMENT OF PERIGEE IN DEGREES
C     COLUMNS 41-48 TOLERANCE FOR MEAN ANOMALY IN DEGREES
C             FORMAT IS 6D8.2
C
```

```
C                        CARD 7
C
C
C
C
C   CARD NO. 7  ORBIT,OBJECT AND EPOCH CARD
C     COLUMNS  1- 3 ORBIT NUMBER
C     COLUMNS  4-11 OBJECT + ORBIT NUMBER (ORBIT NUMBER IS DECIMAL POR-
C                   TION TO 0.001)
C     COLUMNS 12-13 LAST TWO DIGITS OF YEAR
C     COLUMNS 14-15 MONTH
C     COLUMNS 16-17 DAY
C     COLUMN  18    BLANK
C     COLUMNS 19-20 HOUR
C     COLUMNS 21-22 MINUTES
C     COLUMNS 23    BLANK
C     COLUMNS 24-27 SECONDS TO HUNDREDTHS OF SECONDS. NO DECIMAL POINT.
```

```
C                        CARDS 8A - 8H
C
C
C
C
C   CARDS NO. 8A THROUGH 8H (8 CARDS)
C     UNITS ARE DEFINED BY QUANTITY IN COLUMNS 16-18 OF CARD NO.2(THE
C     RUN CONTROL CARD).
C     THE FORMAT OF EACH OF CARDS 8A-8H IS 3D24.17.
C
C                A = SEMIMAJOR AXIS
C                E = ECCENTRICITY
C                I  =  INCLINATION TO THE EQUATOR
C                NODE = RIGHT ASCENSION OF ASCENDING NODE
C                OMEGA = ARGUMENT OF PERIGEE
C                M = MEAN ANOMALY
```

```
C                        CARDS 8A - 8H (CONTINUED)
C
C
C
C
C      CARD 8A (COLUMNS 1-3 OF CARD 2 CONTAIN EITHER +01 OR +04)
C          COLUMNS  1-24 OSCULATING (+01) OR BROUWER MEAN (+04) A
C          COLUMNS 25-48 OSCULATING (+01) OR BROUWER MEAN (+04) E
C          COLUMNS 49-72 OSCULATING (+01) OR BROUWER MEAN (+04) I
C
C      CARD 8B (COLUMNS 1-3 OF CARD 2 CONTAIN EITHER +01 OR +04 )
C          COLUMNS  1-24 OSCULATING (+01) OR BROUWER MEAN (+04) NODE
C          COLUMNS 25-48 OSCULATING (+01) OR BROUWER MEAN (+04) OMEGA
C          COLUMNS 49-72 OSCULATING (+01) OR BROUWER MEAN (+04) M
C          NOTE: THESE COMPONENTS ARE AT EPOCH REFERRED TO THE EQUATOR
C                AND EQUINOX.
C
C
C
C      CARD 8A (COLUMNS 1-3 OF CARD 2 CONTAIN +03)
C          COLUMNS  1-24 X COMPONENT OF POSITION VECTOR
C          COLUMNS 25-48 Y COMPONENT OF POSITION VECTOR
C          COLUMNS 49-72 Z COMPONENT OF POSITION VECTOR
C
C      CARD 8B (COLUMNS 1-3 OF CARD 2 CONTAIN +03)
C          COLUMNS  1-24 X COMPONENT OF VELOCITY VECTOR
C                  25-48 Y COMPONENT OF VELOCITY VECTOR
C                  49-72 Z COMPONENT OF VELOCITY VECTOR
C          NOTE: THESE COMPONENTS ARE AT EPOCH REFERRED TO THE EQUATOR
C                AND EQUINOX.
```

```
C                        CARDS 8A - 8H (CONTINUED)
C
C
C
C
C     FOR ALL VALUES IN COLUMNS 1-3 OF CARD 2:
C     CARD 8C
C          COLUMNS  1-24 COEFFICIENT OF LINEAR TERM IN A
C          COLUMNS 25-48 COEFFICIENT OF LINEAR TERM IN E
C          COLUMNS 49-72 COEFFICIENT OF LINEAR TERM IN I
C
C     CARD 8D
C          COLUMNS  1-24 COEFFICIENT OF ADDITIONAL LINEAR TERM  IN NODE
C          COLUMNS 25-48 COEFFICIENT OF ADDITIONAL LINEAR TERM  IN OMEGA
C          COLUMNS 49-72 COEFFICIENT OF ADDITIONAL LINEAR TERM  IN M
C
C     CARD 8E
C          COLUMNS  1-24 COEFFICIENT OF QUADRATIC TERM  IN A
C          COLUMNS 25-48 COEFFICIENT OF QUADRATIC TERM  IN E
C          COLUMNS 49-72 COEFFICIENT OF QUADRATIC TERM  IN I
C
C     CARD 8F
C          COLUMNS  1-24 COEFFICIENT OF QUADRATIC TERM  IN NODE
C          COLUMNS 25-48 COEFFICIENT OF QUADRATIC TERM  IN OMEGA
C          COLUMNS 49-72 COEFFICIENT OF QUADRATIC TERM  IN M
C
C     CARD 8G
C          COLUMNS  1-24 COEFFICIENT OF CUBIC TERM  IN A
C          COLUMNS 25-48 COEFFICIENT OF CUBIC TERM  IN E
C          COLUMNS 49-72 COEFFICIENT OF CUBIC TERM  IN I
C
C     CARD 8H
C          COLUMNS  1-24 COEFFICIENT OF CUBIC TERM  IN NODE
C          COLUMNS 25-48 COEFFICIENT OF CUBIC TERM  IN OMEGA
C          COLUMNS 49-72 COEFFICIENT OF CUBIC TERM  IN M
```

```
C                        CARDS 8I - 8J
C
C
C
C
C     CARDS 8I-8J SUPPLEMENTARY PERTURBATIONS INFORMATION CARDS.
C              NO.E;THESE CARDS ARE REQUIRED IF AND ONLY IF COLUMNS 34-36
C                   OF CARD NO. 2(THE RUN CONTROL CARD) CONTAIN A QUANTI-
C                  TY OTHER THAN 0.
C   CARD 8I
C            MAXIMUM NUMBER OF ARGUMENTS IS 99.
C         COLUMNS 1-6  NUMBER OF ARGUMENTS OCCURRING IN SUPPLEMENTARY
C                      PERTURBATIONS.
C
C                      EACH ARGUMENT REQUIRES 3 ADDITIONAL CARDS.  THESE
C                      3 ADDITIONAL CARDS ARE 8J1,8J2,8J3.
C
C
C      CARD 8J1
C         COLUMNS  1-24 JULIAN DAY OF EPOCH OF ARGUMENT
C         COLUMNS 25-34 VALUE OF ARGUMENT AT EPOCH IN DEGREES
C         COLUMNS 35-48 MOTION OF ARGUMENT IN DEGREES PER HOUR
C                       FORMAT IS D24.17,F10.6,F14.8.
C
C      CARD 8J2
C         COLUMNS  1-12  COEFFICIENT OF COSINE OF ARGUMENT IN A(MEGA-
C                                                              METERS)
C         COLUMNS 13-24  COEFFICIENT OF COSINE OF ARGUMENT IN E
C         COLUMNS 25-36  COEFFICIENT OF COSINE OF ARGUMENT IN I(DEGREES)
C         COLUMNS 37-47  COEFFICIENT OF COSINE OF ARGUMENT IN NODE(DE-
C                                                                GREES)
C         COLUMNS 48-58  COEFFICIENT OF COSINE OF ARGUMENT IN OMEGA
C                                                              (DEGREES)
C         COLUMNS 59-69  COEFFICIENT OF COSINE OF ARGUMENT IN M(DEGREES)
C           FORMAT IS F14.10,F12.9,F13.8,3F11.6
C
C      CARD 8J3
C        COLUMNS   1-12  COEFFICIENT OF SINE OF ARGUMENT IN A(MEGA-
C                                                            METERS)
C        COLUMNS  13-24  COEFFICIENT OF SINE OF ARGUMENT IN E
C         COLUMNS 25-36  COEFFICIENT OF SINE OF ARGUMENT IN I(DEGREES)
C         COLUMNS 37-47  COEFFICIENT OF SINE OF ARGUMENT IN NODE(DE-
C                                                              GREES)
C         COLUMNS 48-58  COEFFICIENT OF SINE OF ARGUMENT IN OMEGA(DE-
C                                                              GREES)
C         COLUMNS 59-69  COEFFICIENT OF SINE OF ARGUMENT IN M(DEGREES)
C           FORMAT IS F14.10,F12.9,F13.8,3F11.6
C
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```
C                      CARD 9
C
C
C
C
C   CARD NO. 9 EPHEMERIS REQUEST CARD (ONE EMPHEMERIS REQUEST CARD IS
C          REQUIRED FOR EACH EPHEMERIS TO BE COMPUTED)
C        COLUMN    1     BLANK
C        COLUMNS   2- 3 MONTH OF START TIME
C        COLUMN    4     BLANK
C        COLUMNS   5- 6 DAY OF START TIME
C        COLUMN    7     BLANK
C        COLUMNS   8-11 YEAR OF START TIME
C        COLUMN   12     BLANK
C        COLUMNS  13-14 HOUR OF START TIME
C        COLUMN   15     BLANK
C        COLUMNS  16-17 MINUTES OF START TIME
C        COLUMN   18     BLANK
C        COLUMNS  19-24 SECONDS OF START TIME TO THOUSANDTHS
C                       DECIMAL POINT IN COLUMN 21
C        COLUMN   25     BLANK
C        COLUMNS  26-27 MONTH OF END TIME
C        COLUMN   28     BLANK
C        COLUMNS  29-30 DAY OF END TIME
C        COLUMN   31     BLANK
C        COLUMNS  32-35 YEAR OF END TIME
C        COLUMN   36     BLANK
C        COLUMNS  37-38 HOUR OF END TIME
C        COLUMN   39     BLANK
C        COLUMNS  40-41 MINUTES OF END TIME
C        COLUMN   42     BLANK
C        COLUMNS  43-48 SECONDS OF END TIME TO THOUSANDTHS
C                       DECIMAL POINT IN COLUMN 45
C        COLUMNS  49-59 INCREMENT OF TIME IN SECONDS AND THOUSANDTHS OF
C                       SECONDS. (DECIMAL POINT IN COLUMN 56)
C        COLUMNS  60-65 FREQUENCY OF DATA IN EPHEMERIS INDICATOR
C                    0 OR A NEGATIVE INTEGER = DATA FOR EVERY DATE WILL
C                                              BE PRINTED.
C                    A POSITIVE INTEGER GREATER THAN 1(CALL THIS INTEGER
C                    KPR) = DATA FOR EVERY KPR'TH DATE WILL BE PRINTED.
C        COLUMNS  66-72 EPHEMERIS REQUEST SENTINEL.
C                    0= THIS IS THE FINAL EPHEMERIS REQUEST
C                    OTHER THAN ZERO = THIS IS NOT THE FINAL EPHEMERIS
C                                      REQUEST.
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APPENDIX C

MATHEMATICAL DETAILS OF MODIFICATION OF THE BROUWER THEORY

APPENDIX C

Mathematical Details of Modification of the Brouwer Theory

The unit of length in this section is the mean equatorial radius of the earth. Let the quantities designated in Section 2 by

$$a_0,\ e_0,\ I_0$$

be designated here by

$$A'',\ E'',\ I''$$

They are the constant terms in the expressions in the Brouwer theory for a, e, I. Introduce the quantities

$$\epsilon'',\ P'',\ \Theta''$$

by means of

$$\begin{aligned} \epsilon'' &= (1 - E''^2)^{1/2} \\ P'' &= A''\ \epsilon''^2 \\ \Theta'' &= \cos I'' \end{aligned} \tag{C-1}$$

The Keplerian mean motion n_0 is then given by

$$n_0 = \mu^{1/2}\ A''^{-3/2} \tag{C-2}$$

where μ is the constant appearing in (1). With the adopted unit for lengths and any unit for time μ is determined.

The mean motion of the mean anomaly ℓ_B as used in the Brouwer theory is the first time derivative of the secular portion ℓ''_B of ℓ_B and is given by

$$\frac{d\ell''_B}{dt} = n_0\ \{1 + J_2\ B_{21} + J_2^2\ B_{22} + J_4\ B_4\} \tag{C-3}$$

where

$$B_{21} = \frac{3}{4} P''^{-2} \epsilon'' (-1 + 3\Theta''^2)$$

$$B_{22} = \frac{3}{128} P''^{-4} \epsilon'' [(-15 + 16\epsilon'' + 25\epsilon''^2) + (30 - 96\epsilon'' - 90\epsilon''^2)\Theta''^2 + (105 + 144\epsilon'' + 25\epsilon''^2)\Theta''^4] \quad \text{(C-4)}$$

$$B_4 = -\frac{45}{128} P''^{-4} \epsilon'' E''^2 [3 - 30\Theta''^2 + 35\Theta''^4]$$

Kozai like Brouwer uses as basic dependent variables the Delaunay variables

$$L,\ G,\ H,\ l,\ g,\ h$$

defined by (13).

The complete solutions for L, G, H, l, g, h according to Kozai are of the form

$$L = L'' + \delta L, \quad l = l'' + \delta l$$
$$G = G'' + \delta G, \quad g = g'' + \delta g \quad \text{(C-5)}$$
$$H = H'', \quad h = h'' + \delta h$$

Here L'', G'', H'' are constants and l'', g'', h'' are linear functions of the time. Whereas δG, δl, δg, δh contain long- and short-period perturbations, there are only short-period terms present in δL.

The secular portions of a, e, i are designated by double primes and equations for the quantities

$$a'',\ e'',\ i''$$

are obtained from(13) by replacing L, G, H by L'', G'', H'' and a, e, I by a'', e'', i''.

Then p'', η'', θ'' are introduced by means of

$$p'' = a'' (1 - e''^2)$$

$$\eta'' = \frac{G''}{L''} = (1 - e''^2)^{1/2} \qquad \text{(C-6)}$$

$$\theta'' = \cos i'' = H''/G''$$

The quantity n'' is defined by

$$n'' = \mu^2 L''^{-3} = \mu^{1/2} a''^{-3/2} \qquad \text{(C-7)}$$

For the computation of the mean motion of the mean anomaly from equation (7.1) in Kozai's article seventeen functions M_i, $i = 0, 1, \ldots 16$ are introduced. They are defined by

$$M_0 = 1 - 5\theta''^2 \qquad M_1 = e'' (1 - \theta''^2) (1 - 5\theta''^2)^{-2} = e'' (1 - \theta''^2)/M_0^2$$

$$M_2 = 3 (1 - \theta''^2) \qquad M_3 = 1 - 15\theta''^2 \qquad M_4 = 5 (1 - 7\theta''^2)$$

$$M_5 = 2 e''^2 (1 - 5\theta''^2)^{-1} = 2 e''^2/M_0$$

$$M_6 = (1 - 43\theta''^2 + 155\theta''^4 - 225\theta''^6) (1 - 15\theta''^2) = (1 - 43\theta''^2 + 155\theta''^4 - 225\theta''^6) M_3$$

$$M_7 = 10 (1 - 42\theta''^2 + 408\theta''^4 - 1270\theta''^6 + 1575\theta''^8) \qquad \text{(C-8)}$$

$$M_8 = 25 (1 - 19\theta''^2 + 75\theta''^4 - 105\theta''^6) (1 - 7\theta''^2) = 5 (1 - 19\theta''^2 + 75\theta''^4 - 105\theta''^6) M_4$$

$$M_9 = e''^{-1} (1 - \theta''^2 - 2 e''^2 \theta''^2) \qquad M_{10} = 16 [(32 - 59\theta''^2) + 6 e''^2 (8 - 13\theta''^2)]$$

$$M_{11} = 4 (1 - \theta''^2) (1 - 5\theta''^2)^{-2} = \frac{4}{3} M_2/M_0^2 \qquad M_{12} = e''^2 (1 - 5\theta''^2)^{-3} = e''^2/M_0^3$$

$$M_{13} = (4 - 127\theta''^2 + 480\theta''^4 - 525\theta''^6) M_3$$

$$M_{14} = 10 (4 - 139\theta''^2 + 1273\theta''^4 - 3805\theta''^6 + 3675\theta''^8)$$

$$M_{15} = 5 (4 - 63\theta''^2 + 232\theta''^4 - 245\theta''^6) M_4$$

$$M_{16} = - (1 - \theta''^2)^{-1/2} \theta'' [2 (1 - \theta''^2) + e''^2 (2 - 3\theta''^2)]$$

Then the auxiliary constants

$$a_0,\ e_0,\ i_0,\ p_0,$$

defined by equations (6.27) - (6.30) in Kozai's article and the constants

$$\eta_0,\ \theta_0$$

are obtained by successive approximations from

$$a_0 = a'' \left[1 + \frac{3}{4 p_0^2} (1 - e_0^2)^{1/2} (1 - 3\theta_0^2)\, J_2\right]$$

$$e_0 = e'' + (J_2^2/1024\, a''\, p''^3)\, M_1 \left\{M_2 \left[M_3 + \frac{J_4}{J_2} M_4\right]^2 + M_5 \left[M_6 + M_7 \frac{J_4}{J_2^2} + M_8 \left(\frac{J_4}{J_2^2}\right)^2\right]\right\}$$

$$+ (J_3^2/J_2^2)\, (1/16\, a''\, p'')\, M_9 \qquad \text{(C-9)}$$

$$i_0 = i'' - (J_2^2/2048\, p''^4) \sin 2i''$$

$$\times \left\{M_{10} + M_{11} \left[M_3 + M_4 \frac{J_4}{J_2^2}\right]^2 + M_{12} \left[M_{13} + M_{14} \frac{J_4}{J_2} + M_{15} \left(\frac{J_4}{J_2}\right)^2\right]\right\}$$

$$+ (J_3^2/J_2^2)\, (1/16\, p''^2)\, M_{16}$$

$$p_0 = a_0 (1 - e_0^2)$$

$$\eta_0 = (1 - e_0^2)^{1/2}$$

$$\theta_0 = \cos i_0$$

The mean motion of the mean anomaly as used in the Kozai theory will be denoted now by $d\ell_K/dt$ and is equal to the first derivative of the secular portion ℓ''_K of ℓ_K and is given according to equation (7.1) in Kozai's article by

$$\frac{d\ell''_K}{dt} = n''_0 \{1 + K_{21} J_2 + K_{22} J_2^2 + K_4 J_4\} \tag{C-10}$$

where

$$K_{21} = -\frac{3}{4 p_0^2} \eta_0 (1 - 3\theta_0^2)$$

$$K_{22} = \frac{3}{128 p_0^4} \eta_0 [10 (1 - 6\theta_0^2 + 13\theta_0^4) - 5 e_0^2 (5 - 18\theta_0^2 + 5\theta_0^4) - 32 \eta_0 (1 - 3\theta_0^2)^2] \tag{C-11}$$

$$K_4 = -\frac{45}{128 p_0^4} e_0^2 \eta_0 (3 - 30\theta_0^2 + 35\theta_0^4)$$

In the expression for K_4 Kozai's p_0^2 has been replaced by p_0^4.

If the Brouwer theory is modified so that the second order short-period terms in a are included, then it may not be unreasonable to assume that

$$a''_0 = A'' \tag{C-12}$$

and that

$$e''_0 = E'', \quad i''_0 = I'' \text{ to order } J_2 \tag{C-13}$$

Then from (C-2), (C-7), (C-12)

$$n_0 = n'' \tag{C-14}$$

so that (C-3) and (C-10) lead to

$$\delta n = \frac{d\ell''_K}{dt} - \frac{d\ell''_B}{dt}$$

$$= n_0 \{(K_{21} - B_{21}) J_2 + (K_{22} - B_{22}) J_2^2 + (K_4 - B_4) J_4\} \tag{C-15}$$

According to (C-13) $e'' - E''$ and $i'' - I''$ are of order J_2^2 and according to (C-9) the quantities δe and δi defined by

$$\delta e = e_0 - e''$$

$$\delta i = i_0 - i'' \tag{C-16}$$

and

$$\delta\Theta = -\sin I'' \, \delta i \tag{C-17}$$

are of order J_2^2.

It may be conceivable that the differences $e'' - E''$ and $i'' - I''$ are even smaller than the second order of J_2. Only if we make this assumption will we be able to derive a fairly simple approximation for $d\ell''_K/dt - d\ell''_B/dt$. The assumption implies

$$e_0 = E'' + \delta e$$

$$i_0 = I'' + \delta i \tag{C-18}$$

$$\theta_0 = \Theta'' + \delta\Theta$$

where δe and δi are computed from (C-16) and $\delta\theta$ from (C-17). Using two successive iterations of (C9) we find that to order J_2^2

$$a_0 = A'' \, [1 + \gamma J_2 - 2 \gamma^2 J_2^2] \tag{C-19}$$

where

$$\gamma = \frac{3 \epsilon''}{4 P''^2} (1 - 3\Theta''^2) \tag{C-20}$$

Then we obtain the following correction

$$\delta n = n_0 \left\{ J_2^3 (\gamma^3 - 4\gamma B_{22}) - 4 B_4 \gamma J_2 J_4 + \frac{3E''}{\epsilon''^2} J_2 \delta e - \frac{6\Theta''}{1 - 3\Theta''^2} J_2 \delta\Theta \right\} \quad \text{(C-21)}$$

to the mean motion of the mean anomaly computed according to Brouwer. This correction will probably make the mean motion to be closer to the value according to Kozai.

To free oneself from above assumptions, one would have to make use of more portions of the Kozai theory. This probably would mean so much involvement with the Kozai theory that it might just as well be used exclusively and the purpose of deriving a reduction from Brouwer's to Kozai's mean motion would be defeated.

The long period portions $L', G', H', \ell', g', h'$ of L, G, H, ℓ, g, h are given by

$$\begin{aligned} L' &= L'' \quad , \quad \ell' = \ell'' + \delta_L \ell \\ G' &= G'' + \delta_L G \, , \quad g' = g'' + \delta_L g \\ H' &= H'' \quad , \quad h' = h'' + \delta_L h \end{aligned} \quad \text{(C-22)}$$

there being no long-period perturbations in L and H.

The quantities

$$\delta_L G, \ \delta_L \ell, \ \delta_L g, \ \delta_L h$$

are the long-period perturbations in G, ℓ, g, h.

We define

$$a', \ e', \ i'$$

by means of (13) by replacing L, G, H, a, e, I by the primed quantities L', G', H', a', e', i'. We also introduce η', θ' by means of

$$\begin{aligned} \eta' &= (1 - e'^2)^{1/2} = G'/L' \\ \theta' &= H''/G' = \cos i' \end{aligned} \quad \text{(C-23)}$$

Let f' be the true anomaly and $\rho' = r'/a'$ the ratio r/a computed from e' and ℓ'. Finally define g^*, B'_{20}, B'_{22} by

$$g^* = g' - \frac{3\mu^2 J_2}{4G'^4}(1 - 5\theta'^2)(f' - \ell')$$

$$B'_{20} = -\frac{1}{4}(1 - 3\theta'^2) \qquad \text{(C-24)}$$

$$B'_{22} = \frac{3}{4}(1 - \theta'^2)$$

The perturbations δL of L, which consist of short-period terms, are then given by (see equation (3.8) in Kozai's article)

$$\delta L = \frac{\mu^2 J_2}{L'^3}\left\{B'_{20}\left[\frac{a'^3}{r'^3} - \eta'^{-3}\right] + B'_{22}\frac{a'^3}{r'^3}\cos 2(f' + g^*)\right\} + \delta_2 L \qquad \text{(C-25)}$$

where $\delta_2 L$ are second order terms due to J_2^2, J_3, J_4. They have been programmed for an electronic computer by Agreen and Fisher (1968).

The first term of the right hand member of (C-25) represents the first order term in δL according to Kozai. Brouwer who uses only first order terms in δL which he then converts to a perturbation in a uses a similar expression but instead of g^* he uses g'. In order to facilitate comparison of Kozai's expression for δL with Brouwer's expression to be given below we rewrite (C-25) and make use of (C-24). We then obtain

$$\delta L = \delta_1 L + \delta'_2 L + \delta_2 L \qquad \text{(C-26)}$$

where

$$\delta_1 L = \frac{\mu J_2}{4L'a'}\{(-1 + 3\theta'^2)(\rho'^{-3} - \eta'^{-3}) + 3(1 - \theta'^2)\rho'^{-3}\cos 2(f' + g')\} \qquad \text{(C-27)}$$

and

$$\delta'_2 L = \frac{9}{8}\frac{\mu^4 J_2^2}{G'^7}\frac{a'^3}{r'^3}\eta'^3(1 - 5\theta'^2)(1 - \theta'^2)(f' - \ell')\sin 2(f' + g') \qquad \text{(C-28)}$$

The quantity $\delta_2' L$ represents the reduction of the first order term of (C-25) with g^* replaced by g' to the form as it appears in (C-25).

From (13) and (C-26) we obtain to the second order

$$a = a'' + \delta_1 a + \frac{1}{\mu} 2L'' (\delta_2' L + \delta_2 L) + \frac{\delta_1^2 a}{4 a''} \tag{C-29}$$

where

$$\delta_1 a = \frac{2L' \delta_1 L}{\mu} = \frac{1}{2} \frac{J_2}{a'} \{(-1 + 3\theta'^2)(\rho'^{-3} - \eta'^{-3}) + 3(1 - \theta'^2) \rho'^{-3} \cos 2(f' + g')\}$$

$$= J_2 \phi \left(a', \theta', \eta', \frac{r'}{a'}, f', g'\right) \tag{C-30}$$

Here

$$\phi \left(a, \theta, \eta, \frac{r}{a}, f, g\right) = \frac{1}{2a} \left\{(-1 + 3\theta^2) \left(\frac{a}{r} - \eta^{-3}\right) + 3(1 - \theta^2) \frac{a^3}{r^3} \cos 2(f + g)\right\} \tag{C-31}$$

Here r/a and f are the ratio of radius vector and semi-major axis and the true anomaly computed from the eccentricity and mean anomaly according to the laws of Keplerian motion.

According to the Brouwer theory

$$a = A'' + \delta_s A \tag{C-32}$$

where $\delta_s A$ are the short-period terms in a assumed to be computed with e', I'. This expression is

$$\delta_s A = J_2 \phi \left(A', \Theta', \epsilon', \frac{r'}{A'}, f', g'_B\right) \tag{C-33}$$

where ϕ is the same function as the one appearing in (C-30), where g'_B is the long-period portion of g, according to Brouwer, and where r'/A' and f' are the ratio of radius vector and semi-major axis and true anomaly computed from the long-period portions of the eccentricity and mean anomaly.

From (C-29) and (C-32) follows

$$a'' = A'' + \{(\delta_s A)_0 - (\delta_1 a)_0\} - \frac{1}{\mu} 2L'' \left[(\delta'_2 L)_0 + (\delta_2 L)_0\right] - \frac{(\delta_1 a)_0^2}{4a''} \tag{C-34}$$

where parentheses with subscripts 0 indicate values at the epoch.

Let us assume that the long-period portions of e , i , Ω , ω, M as computed by Brouwer and Kozai differ at most by terms of order J_2, which is a reasonable assumption.

Since in (C-30) and (C-33) occur the same function ϕ the difference $\delta_1 a - \delta_s A$ is at least of order J_2^2. Then (C-34) implies that a'' - A'' will be at least of order J_2^2. Also, the first two terms in the right hand member of (C-29) will be of the same form as the right hand member of (C-32).

Thus while we cannot prove it, it may be conceivably true that to order J_2^2 (C-29) may be replaced by

$$a = A'' + \delta_s A + \frac{1}{\mu} 2L'' (\delta'_2 L + \delta_2 L) + \frac{\delta_s^2 A}{4A''} \tag{C-35}$$

where $\delta'_2 L$, $\delta_2 L$ are based on quantities computed according to Brouwer instead of Kozai. The terms in (C-35) additional to A'' and $\delta_s A$ consisting of second order short-period terms may lead to an improvement of the Brouwer expression for a.

We might note again, that the term with $\delta'_2 L$ allows for the fact that Brouwer uses g' while Kozai uses g^* in the first order perturbations of L. The term $\delta_2 L$ represents the second order terms in L in the Kozai theory due to J_2^2, J_3 , J_4 but based on quantities obtained in the Brouwer theory. The last term in (C-35) is a second order term due to the conversion from L to a.

The modifications of the Brouwer theory given by (C-21) and (C-35) will be tested experimentally. Results will be reported in a later report.

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